METROPOLITAN WATER AND SEWERAGE BOARD

SECOND ANNUAL REPORT

JANUARY 1, 1903

FORBES HILL RESERVOIR AND WATER TOWER IN QUINCY.

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SECOND ANNUAL REPORT

OF THE

METROPOLITAN WATER AND SEWERAGE BOARD.

JANUARY 1, 1903.

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Metropolitan Water and Sewerage Board.

To the Honorable the Senate and House of Representatives of the Commonwealth of Massachusetts in General Court assembled.

The Metropolitan Water and Sewerage Board, established under the provisions of chapter 168 of the Acts of the year 1901, has already presented to your Honorable Body an abstract of the account of its doings, receipts, expenditures, disbursements, assets and liabilities for the calendar year ending December 31, 1902, and now presents a detailed statement of its operations for the year, being its

SECOND ANNUAL REPORT.

The Metropolitan Water Board and the Board of Metropolitan Sewerage Commissioners were consolidated on March 20, 1901, and statements of the previous operations upon the Metropolitan Water Works and upon the Metropolitan Sewerage Works are embraced in the six annual reports of the Metropolitan Water Board and in the twelve annual reports of the Metropolitan Sewerage Commissioners, made prior to the date of consolidation.

I. ORGANIZATION AND ADMINISTRATION.

(1) Board, Officers and Employés.

The membership of the Board has continued as last year; namely, Henry H. Sprague, chairman, Henry P. Walcott, M.D., and James A. Bailey, Jr. William N. Davenport has continued as secretary and executive officer of the Board, and Alfred F. Bridgman as auditor and purchasing agent.

The administrative office force has comprised a book-keeper, two assistant book-keepers, an assistant in auditing, a paymaster, a supply clerk, three general clerks, four stenographers, a telephone operator, two messengers, a janitor and a watchman.

Alfred C. Vinton, conveyancer, and George D. Bigelow, assistant conveyancer, have continued in charge of the work of conveyancing

of the Board. They have been assisted by Miss Alline E. Marcy, title examiner, by one stenographer, and by Miss Celia M. Tibbetts, who is employed a part of the time for service at the Worcester Registry of Deeds.

Frederic P. Stearns has continued as chief engineer of the Board, with special charge of the Water Works, and Joseph P. Davis, Alphonse Fteley and Hiram F. Mills are still retained to act as consulting engineers when their services are required.

For the Water Works the following have also been in charge of the various departments: Dexter Brackett, engineer of the Distribution Department; Thomas F. Richardson, engineer of the Dam and Aqueduct Department; Hiram A. Miller, engineer of the Reservoir Department; Horace Ropes, engineer of the Weston Aqueduct Department. Alfred D. Flinn occupied the position of principal office assistant until his resignation on October 6, 1902, when the position was taken by Frank T. Daniels.

Desmond FitzGerald was in charge of the Sudbury Department until November 15, when, on account of ill health, his resignation as engineer of the department was accepted. Mr. FitzGerald, who had for a long period of years been closely identified with the construction and maintenance of the Boston Water Works, was, upon the organization of the Metropolitan Water Board, placed in charge of construction and maintenance in the Sudbury Department, and he has given a valuable and distinguished service, both to the city of Boston and the whole Metropolitan District.

The engineering force employed on the Water Works, in construction and maintenance, has, upon the average during the year, comprised, in addition, 12 division engineers, 26 assistant engineers, and others in various engineering capacities and as sanitary inspectors, clerks, stenographers and messengers, to the number of 154, — in all, 192. The maximum engineering force employed at any one time during the year on construction and maintenance was 236.

There have also been employed inspectors, other than engineering inspectors, to the maximum number of 27. Day-labor forces under the general supervision of the engineers and the immediate direction of foremen, varying in numbers from time to time, have been employed in pipe laying, in general improvements and repairs and in the performance of minor operations.

In addition, a regular maintenance force has been required at the pumping stations and upon the reservoirs, aqueducts, pipe lines and other works, numbering upon the average during the year 179. This force at the end of the year numbered 202, and was distributed among the various departments as follows: Distribution Department, 97; Dam and Aqueduct Department, 10; Sudbury Department, 94; Reservoir Department, 1.

The maximum number of men employed upon contracts by the various contractors upon the Water Works during the year was for the week ending August 2, when the number amounted to 3,894.

William M. Brown, engineer of the Sewerage Works, has been in charge of both construction and maintenance upon these works.

He has been assisted by 6 division engineers, who have been in charge of the various sections of sewer construction, 14 assistant engineers, and 90 others, who are employed in various engineering capacities, and as clerk, stenographer and messenger in the department. The maximum engineering force employed at any one time during the year on construction and maintenance of the Sewerage Works was 110.

There have also been employed inspectors, other than engineering inspectors, to the maximum number of 24. Day-labor forces, under the general supervision of the engineers and the immediate direction of foremen, have been employed in the construction of the tunnel forming a part of Section 73 in Jamaica Plain, on Section 67 in the pipe crossing of Stony Brook in Hyde Park, and on Section 64 in the crossing of the Neponset River in Hyde Park and Milton, all for the High-level sewer, and in other minor work.

The regular maintenance force required for the pumping stations, sewers and other parts of the Sewerage Works, exclusive of engineers and day-labor construction forces before enumerated, has upon the average numbered 87. This force at the end of the year numbered 86, and was distributed between the two departments as follows: North Metropolitan System, 72; South Metropolitan System, 14.

The maximum number of men employed upon contracts by the various contractors upon the Sewerage Works during the year was for the week ending August 9, 1902, when the number amounted to 1,577.

(2) Offices and Buildings.

The office of the Metropolitan Water and Sewerage Board is in the buildings numbered 1 and 3 Ashburton Place, at the corner of Somerset Street. In these buildings are also located the offices of the secretary, the auditor and the conveyancers, and the main engineering office of the Metropolitan Water Works. The engineering department of the Sewerage Works occupies rooms in the Pemberton Building in Pemberton Square.

The headquarters of the Wachusett Reservoir and Wachusett Dam and Aqueduct departments of the Water Works have been maintained in the office building in Clinton. Branch offices of the Wachusett Reservoir Department have been maintained, one at the North Dike in Clinton, one at Sawyer's Mills in Boylston, and two in West Boylston, and a fifth was established in April in Oakdale. For the work of the Wachusett Dam and Aqueduct Department a branch office has been maintained at the dam. The main office of the Western Aqueduct Department has remained in Saxonville, and branch offices have been located in Framingham Centre, Wayland and Weston. Headquarters of the Distribution and Sudbury departments have been maintained in Boston. For the Sudbury Department a branch office has been maintained at South Framingham. The headquarters for distribution of the maintenance department of the Water Works in the northern part of the District have been in buildings in the Glenwood Pipe Yard in Medford, where there are offices, shops, store rooms and stables. The maintenance force for the southern portion of the District has its headquarters in buildings at the Chestnut Hill Reservoir.

There are also maintained, in connection with the Water Works, the Chestnut Hill high-service and low-service pumping stations; the Spot Pond, Arlington and West Roxbury pumping stations; the Clinton sewerage pumping station at Clinton; the Mystic pumping station at Medford, not now operated; as well as the gate-houses at the several reservoirs, dwellings for attendants, and various other buildings for operating purposes.

There have been maintained, in connection with the construction of the Sewerage Works, branch engineering offices at East Milton, Hyde Park and Hough's Neck, and, for a portion of the year, at Forest Hills. In addition to the above, twenty-two portable booths

have been in use along the line of the work. For the operation of the works there have been maintained the Deer Island, Charlestown, East Boston, Alewife Brook and Quincy pumping stations.

(3) Conveyancing.

The larger part of the work of the conveyancers of the Board has been devoted to the settlements of claims for damages, of which a larger number has been made than in any previous year. The titles to the estates on account of which settlements have been effected have been brought up to date, and the various papers have been drafted. The larger part of these settlements referred to lands in Sterling and West Boylston, for which depreciation was claimed; to lands taken for, or affected by building, the Weston Aqueduct; and to the relocation of the Central Massachusetts Railroad.

Settlement has been effected in 158 cases, for which titles were completed and the necessary papers drafted. Of these settlements, 147 were made on account of the Water Works, and 11 on account of the Sewerage Works. The 147 cases on account of the Water Works affected 3,147.929 acres, and the 11 cases on account of the Sewerage Works affected 5.365 acres. Of the cases which were considered, 18 were pending settlement on January 1, 1903.

A great deal of work has also been required to be done in connection with the Attorney-General's office, in the preparation of reports upon titles prior to the trial of cases in court. Reports were made to the Attorney-General in 75 cases.

There have been drafted 17 instruments of takings of lands and rights in lands, — 15 for the Water Works and 2 for the Sewerage Works. Of these takings, 8 were of easements for the construction of pipe lines, 3 of lands for the Weston Aqueduct, 2 of lands for the Wachusett Reservoir, 1 each for the relocation of the Central Massachusetts Railroad and for the Spot Pond Improvement, and 2 for the High-level sewer.

There have also been drafted 3 locations of roads and 3 discontinuances of roads.

A detailed statement of the various takings and settlements is given hereafter.

II. WATER WORKS — CONSTRUCTION.

(1) Wachusett Dam and Reservoir.

(a) *Wachusett Dam.*

During the year 1901 excavation for the bed of the structure had been completed, and masonry had been laid to the extent of more than 28,000 cubic yards and had reached the height of about 40 feet above the bed rock. During the past year more than 65,000 cubic yards of rubble-stone masonry have been laid, and the dam has reached in general a height above the bed rock of 96 feet.

There has been considerable excavation made for extending the masonry into the banks in cut-offs on both sides of the valley.

The cast-iron pipes, which pass through the dam from the upper to the lower gate-chambers, have been put in place. The foundations of the lower gate-chamber and power house have been completed, and the pipes which are to extend through the lower chamber to the circular pool below the dam, as well as the pool itself, have been largely constructed.

The dam has been carried to such a height that it has been necessary to remove the large flume and waste-way, which had been originally constructed, and also to remove a part of the smaller flume which carried the water from the temporary dam into the head of the Wachusett Aqueduct. The water is now introduced into the aqueduct by way of the pipes carried through the dam and the lower gate chamber; and the overflow or waste from the river must now pass over a portion of the dam which has been carried to a less height than the remainder of the structure. It is still possible to regulate the height of the water in the river at the temporary dam.

(b) *Wachusett Reservoir.*

The stripping and removal of the soil from the bottom of the Wachusett Reservoir has been carried on during the year principally within the limits of the town of Boylston. The stripping has, however, extended somewhat into the easterly part of the town of West Boylston; and small areas in the westerly part of the reservoir in West Boylston, and also in the town of Clinton, have been stripped during the year.

The work of building the North Dike has been continued, and the

WACHUSETT DAM — UP-STREAM SIDE, VIEW OF DAM WITH GAP FOR PASSAGE OF FLOODS. IN BACKGROUND, GRANITE ABUTMENT AND PIERS FOR RAILROAD VIADUCT.

main cut-off trench as well as the secondary cut-off trench have been substantially completed. The larger part of the material required for the extended embankment upon the land side has been deposited, and considerable progress has been made in depositing gravel upon the water slopes of the dike, as well as riprap for their immediate protection against the wave action of the water.

It is estimated that more than 90 per cent. of the total amount of soil filling which is required for the North Dike has been already deposited.

In stripping the land which is to be submerged in the reservoir, it is expected to remove the soil from 4,200 acres, requiring the removal, as is estimated, of 6,900,000 cubic yards of earth. During the year 1902, 715 acres were stripped, from which were removed 1,246,931 cubic yards. The soil has now been removed from nearly 68 per cent. of the entire area to be stripped, and about 70 per cent. of the whole amount of soil has been removed.

The contracts which have been made in the past and preceding years have provided for the removal of substantially all the soil, there being excepted only a small quantity about the margins of the Oakdale mill pond at the extreme upper end, and in the easterly portion of the reservoir where soil is to be used for the construction of the South Dike.

The contracts provide that the stripping of the most remote and highest portions of the bed of the reservoir shall be completed on or before November 1, 1905.

A small portion of the soil has been removed in carts, but the larger portion has been loaded directly into cars, or first loaded into carts and dumped into cars at dumping platforms. The larger part of the soil, constituting 93 per cent. of the amount removed, has been carried by locomotives to the North Dike. The remainder has been used for highway and railroad embankments, and for filling small shallow flowage areas. In the few places where muck has been found at a depth so great that it was not feasible or necessary to remove it, it has been covered with gravel or sand.

The houses which have remained standing in the reservoir site have, in general, been rented during the year to employés of the Board or to contractors engaged upon the work, and a considerable income has been gained from this source. The progress of the work, however, requires the gradual removal of the buildings. During the past year 35 dwelling houses, 11 barns, 5 shops, 4 stores, 1

mill and 3 halls — a total of 59 buildings in West Boylston — have been torn down or removed, making a total of 209 destroyed or removed since the beginning of the work in that town. During the year, also, the dams formerly belonging to the West Boylston Manufacturing Company, the two dams of the L. M. Harris Manufacturing Company, and the dam of the Rice and Cowee mills, have been removed.

Trees and bushes have been cut in many places along the margin of the land purchased by the Board, so as to establish a fire guard 40 feet wide as a protection against the spread of fire. The trees and brush were removed during the past year for a distance of 1.49 miles, which is in addition to the 13.49 miles from which they had been removed for a fire guard in previous years.

A large number of seedlings, principally white pine, maple, oak and chestnut, have been raised in the two nurseries which have been established upon the lands of the Commonwealth, and a beginning has been made in transplanting these to open tracts about the margin of the reservoir.

(c) *Location, Construction and Discontinuance of Roads.*

Changes in grade have been made in South Main Street, where it is to cross the relocation of the Central Massachusetts Railroad, and slight changes in both location and grade have been made in the South Meadow Road, in order to avoid a crossing of this railroad. Provision has been made for an overhead railroad crossing of Boylston Street near the dam. Changes have also been effected in the road running from West Berlin to Boylston, in order to avoid a grade crossing on the line of the relocation of the railroad in West Berlin.

Plans have been completed for the continuation of the road which runs from Clinton to West Boylston, from the point in the village of West Boylston to which the location had been fixed, to and through the village of Oakdale, and it is expected that the location will be definitely determined and agreed upon at an early date.

Considerable progress has been effected in the building of the road in West Boylston which is to extend from Worcester Street, on the southerly side of the reservoir, across the reservoir to the junction of Sterling and Lancaster streets on the northerly side, and a contract has been made for the building of the high embankments which are required.

During the year, Harris Street in West Boylston and the portion of Holden Street which lies between Harris Street and North Main Street have been discontinued.

The following is a list of roads which have been relocated or altered, with dates of the determinations made, since the beginning of the construction of the Wachusett Reservoir: —

Location of Roads.

No.	LOCATION.	Description.	Date of Acceptance.
1	Boylston, . .	Road running from the point of discontinuance of the River Road in Boylston, northeasterly across the schoolhouse road, to road to Northborough, at land of Janet L. Miller.	June 15, 1897.
2	Boylston and Clinton.	Road running in continuation of preceding road, from the northeasterly end thereof in Boylston, northerly across the railroad, the road to Berlin, and the Clinton boundary line, into, through and westerly of Boylston Street, to its junction with River Street.	April 12, 1898.
3	Clinton, . . .	Road (temporary) running from South Main Street, near land of Kittredge, westerly, across Coachlace Pond, to South Meadow Road.	June 2, 1898.
4	West Boylston and Boylston.	Road (as modified by decree of Highway Commissioners) running from the junction of Temple Street and Worcester State highway, in West Boylston, easterly along Temple Street to Pierce Street, then southerly across Dover Road, the Boylston boundary line and road from Worcester to Boylston, to junction of School Street and South Road, and then along School Street to road to Shrewsbury.	May 6, 1899.
5	Clinton and Sterling.	Road running from South Main Street in Clinton, at land of George A. Dorrison, westerly across Coachlace Pond, and southwesterly across South Meadow Road and Sterling boundary line, to land of late Thomas H. O'Connor.	Dec. 27, 1898.
6	Sterling and West Boylston.	Road from the southwesterly end of the preceding road in Sterling, westerly across the road to Sawyer's Mills, and southwesterly across the West Boylston boundary line, to Lancaster Street at land of Olive A. Hager. Also regrading and partial widening of Lancaster Street to Beaman Street.	Feb. 21, 1899.
7	Clinton, . . .	Addition to the new Road No. 2 at land late of Thomas Pendergast on the westerly side of Boylston Street, to include outlet of culvert.	Feb. 21, 1899.
8	West Boylston, .	Road running from Lancaster Street, at junction of Beaman and Sterling streets, southwesterly through Fletcher Street and Howe Street, across East Main Street, Nashua River, Central Massachusetts Railroad, Prospect Street, Holbrook Street, and Worcester, Nashua & Rochester Railroad, and then southeasterly to Worcester Street, together with branch from Howe Street, parallel with East Main Street, to land of George H. Holmes, and branch northwesterly to Prospect Street, adjoining the Worcester, Nashua & Rochester Railroad.	Nov. 19, 1901.
10	Clinton, . . .	Overgrade railroad crossing at Boylston Street; overgrade crossing over Road No. 5, near South Meadow Road; and undergrade crossing of Road No. 5 at land formerly of John W. Bigelow *et als.*, together with changes of grade; and a new way from the South Meadow Road southeasterly to Road No. 5, — on account of relocation of Central Massachusetts Railroad.	July 22, 1902.
11	Berlin, . . .	Road running from the Boylston Road in West Berlin, northwesterly and then southwesterly across the relocation of the Central Massachusetts Railroad back to the Boylston Road, through land of Jonas H. Carter, — on account of relocation of Central Massachusetts Railroad.	Sept. 9, 1902.

During the year 1902 only two roads have been discontinued on account of the work of construction in the Wachusett Reservoir, as follows: —

No.	LOCATION.	Description.	Date of Discontinuance.
11	West Boylston, .	(1) Harris Street in Oakdale, extending from North Main Street to Holden Street. (2) Part of Holden Street between North Main Street and Harris Street.	June 26, 1902.

Lists of roads discontinued prior to the year 1902 have been published in earlier reports.

(d) *Relocation of the Central Massachusetts Railroad.*

On April 3, 1902, the Board, in accordance with the Metropolitan Water Act, completed an agreement with the board of directors of the Boston & Maine Railroad, for the discontinuance of that portion of the Central Massachusetts Division of the railroad which runs through the site of the Wachusett Reservoir, and for the relocation and construction of the railroad from West Berlin to Oakdale in West Boylston, along the northern side of the reservoir.

The new location determined upon, after leaving a point near the crossing of the Central Massachusetts Railroad over the New York, New Haven & Hartford Railroad in West Berlin, passes over the highway leading to Boylston, and thence, proceeding northerly, follows in general the course of Berlin Street in Berlin; and, crossing the town line into Clinton, proceeds for about 1,500 feet in the same general course, then turns to the left and passes under the Clam Shell Road; and thence by a tunnel under Wilson Street, 1,110 feet long, comes to a point near Boylston Street, which it crosses overhead; and thence is carried by a high steel viaduct, supported upon granite masonry piers, across the Nashua River just below the Wachusett Dam, and passes along the shore of the reservoir and the North Dike, to a junction with the Worcester, Nashua & Rochester Railroad, at a point about 9,631 feet westerly from the present Clinton station on that railroad. A branch line also runs from the main line at the North Dike, upon a curve to the Worcester, Nashua & Rochester Railroad, in order to provide for running trains to the passenger station in Clinton. It was provided that the land should be taken for this portion of the route, and that its construc-

tion should be undertaken by the Board. This section to be built is 3.92 miles in length, and the branch line toward the Clinton station is 0.77 of a mile.

It is agreed that the Board shall be relieved from constructing a railroad from the junction with the Worcester, Nashua & Rochester Railroad to a point in the village of Oakdale, in West Boylston, 300 feet south of the arch where the Stillwater River passes under the railroad, a distance of 4.40 miles, as the trains on the Central Massachusetts Railroad will, for a period at least, run for that distance upon the tracks of the other railroad.

From the above point in Oakdale it is provided that the tracks of the Worcester, Nashua & Rochester Railroad shall be relocated and reconstructed through the village of Oakdale to a point 350 feet beyond and south of the existing crossing of that railroad and the Central Massachusetts Railroad, and that new connections between the railroads shall be constructed. There is also required a considerable reconstruction of the highways in Oakdale, which are to be built over the railroads, so that steel bridges with considerable spans are to be provided. This portion, having a length of 0.55 of a mile, is also to be built by the Board.

The entire length of the relocation will be 8.87 miles, and the new location will be but one-third of a mile longer than the portion discontinued. The new location is shown on an accompanying plan.

In rebuilding, the Board will construct no crossings at grade, and by the relocation seven grade crossings upon the discontinued portions of the Central Massachusetts Railroad and one grade crossing at Oakdale upon the Worcester, Nashua & Rochester Railroad will be abolished.

The corporation is to release to the Commonwealth all the lands, buildings, bridges and other structures embraced within the limits of the portion of the railroad location in the reservoir which is to be discontinued; to reimburse the Commonwealth for the construction of the branch line to Clinton; and to assume all obligations which may arise by reason of the failure of the Board to build a separate line of railroad between the points in Clinton and Oakdale before mentioned, and, in general, from other liabilities imposed upon the Board and the Commonwealth by the Metropolitan Water Act. In consideration of such release and agreement, the Commonwealth is to pay the corporation the sum of $187,000.

Owing to the delay which necessarily occurred in reaching a determination with the officers of the Boston & Maine Railroad, it was necessary to enter upon the work as vigorously as possible after the agreement had been made. The required surveys had been mostly completed, and preparations were at once made for the taking of the necessary pieces of land required in Berlin and Clinton, and for completing the contracts and doing the work.

Much of the engineering and construction required is of a peculiarly difficult character; this is especially the case where the railroad crosses the Nashua River just below the dam. There is easterly of the river a tunnel 1,110 feet long; a steel trestle bridge 917 feet long, with nine spans, crosses the river at a height of 133 feet; then comes a rock cut having a maximum depth of 56 feet; and, for a considerable distance beyond, the route follows the line of the North Dike. It was necessary to arrange the contracts for building these portions so that the work could be carried along in connection with the building of the dam and dike.

The work in Oakdale requires a general rearrangement of the railroads and highways, as well as high embankments and considerable bridges.

The contracts provide that the relocation shall be completed in April of this year, and the work has been so speedily carried on that it is believed that it will be possible to change the running of the trains at some time in the coming spring.

(e) *Clinton Catholic Cemetery.*

By reason of the more complete excavations made upon the site of the St. John's Catholic Cemetery, additional bodies have been found, and have been removed by the representatives of the cemetery association. There seems to be no question but that all the bodies have now been removed. The total number of bodies which have been removed from the cemetery is 3,902.

Although the work of the removal of the bodies from the St. John's Catholic Cemetery in Clinton, which was included within the limits of the Wachusett Reservoir, to the new cemetery in the town of Lancaster, was substantially completed in the year 1900, a final settlement has not been reached under the tripartite agreement between the Board, the Roman Catholic Bishop of Springfield and the St. John's Catholic Cemetery Association. There is a balance due,

which the Board for a considerable period has been ready to pay in accordance with the agreement; and it has been likewise ready to convey the lands held by it, and included within the new cemetery lot, to the St. John's Catholic Cemetery Association, as called for, on the conveyance to the Commonwealth of the old cemetery lot and a release of all claims and damages as provided.

(*f*) *Sanitary Inspection of Watershed.*

Progress has been made in the work of improving the sanitary condition at various mills and dwelling houses situated in the Wachusett watershed. At several mills cesspools have been placed, and other construction has been carried on.

The camps which have been constructed for laborers, and the various buildings in which the laborers upon the work have been lodged, have been subject to inspection by Dr. J. J. Goodwin, and by constant effort they have been kept in a fairly clean condition.

(2) Improvement of Lake Cochituate.

The work of improving the condition of the portions of Lake Cochituate known as Snake Brook Meadow and as Pegan Brook Meadow, under the requirements of chapter 509 of the Acts of the year 1901, has been substantially completed. The Act required that the meadows should be cleaned and excavated to a level of practically 10.33 feet below high water in the lake, provided, however, that the amount to be expended for this purpose should be limited to $100,000, and that the improvements should be effected on or before June 14, 1903.

(*a*) *Snake Brook Meadow.*

The work of improving the Snake Brook Meadow was carried on during the year 1901, and nearly finished. The gravel facing of the embankments, which remained to be done, was finished in January of last year. Considerable work had to be done on account of the settling of the slopes in regrading the embankments which had been completed late in the previous year. As it was found that the excavation could not be carried in the two meadows to a level of 10.33 feet below high water in the lake, the excavation of mud from the Snake Brook Meadow was carried to a depth of 9 feet. The cost of this portion of the work, however, was somewhat less than had been anticipated.

(b) *Pegan Brook Meadow.*

A temporary dam was built, and a main ditch for the drainage of the meadow was begun in the previous year, in order that the bed of the meadow might be made ready for the excavation and removal of the mud as early as possible in the season. Active operations for the removal of the mud were begun in May. For its removal, wheelbarrows, carts and cars were put into requisition, according to the peculiar conditions of the various places. The contractor completed his work on December 20.

Nothing now remains to be done under the requirements of the Act except the small amount of cleaning and trimming up which is naturally done at the beginning of the season following the construction. Inasmuch as the work upon the Snake Brook Meadow was completed at a somewhat less cost than was estimated, the excavation of Pegan Brook Meadow was carried to a somewhat greater extent, and reached a depth of about 9.8 feet. It is probable, however, that this excavation was made rather too deep, and that the total cost of the improvement will very slightly exceed the sum of $100,000.

(c) *Improvement of Pegan Brook Filtration System.*

In connection with the improvement of the Pegan Brook Meadow, as required by the Act of the Legislature, it was thought advisable to better the system by which the water received from Pegan Brook and its vicinity is filtered before entering the lake. An intercepting ditch, about 3,000 feet long, to receive the smaller brooks and surface drainage, has been constructed about the eastern edge of the embankment made in the improvement of the meadow. This intercepting ditch leads from the small pond north of Kansas Street, which has been enlarged and included in the system as an equalizing reservoir, to a receiving reservoir which has been constructed, having a capacity of about 1,000,000 gallons, and which is located near the mouth of Pegan Brook. A new pumping station is to be constructed near the reservoir, at which the water collected from the brook and the intercepting ditch will be pumped into the existing filter beds.

(3) Weston Aqueduct and Reservoir.

It has been necessary to push as fast as possible the operations upon the Weston Aqueduct and Reservoir, in order that they may be completed during the present year.

The character of the work has been such that many difficulties have been encountered.

The tunnels, of which there are five, have offered peculiar difficulties, inasmuch as for considerable distances, where solid rock was anticipated, the surface of the rock was found to exist at varying heights between the floor and roof of the tunnel. Strong and careful timbering was required, and the advance was consequently slow and costly. The aggregate length of the tunnels is 2.3 miles, and the excavation has been carried to the extent of 2.1 miles.

In crossing the valley of the Sudbury River, and of Happy Hollow, so called, in Wayland, riveted steel siphon pipes, 7 ½ feet in diameter, have been laid, in order to avoid the building of the high embankments and bridges which would be required to carry a masonry conduit across the valleys. Three lines of these pipes will ultimately be required, but at present only one is laid, as that will meet the requirements of the District for a considerable period to come. The length of the line across the river is 3,606 feet, and that across Happy Hollow is 1,125 feet.

At the beginning of the past year nearly one-quarter part in length of the aqueduct had been built, and nearly one-half of the entire length has been constructed during the year.

The building of the foundations for the four siphon chambers, for two of the gaging chambers, and for the large terminal chamber at the end of the aqueduct in Weston near the Charles River, has been carried on during the past year, and contracts have been made for building the superstructures.

Somewhat less progress has so far been made upon the equalizing reservoir, which is in process of construction near the easterly or lower end of the aqueduct in the town of Weston. The reservoir and open channel approaching it have an area of 66.6 acres, and the reservoir when completed will have a capacity exceeding 200,000,000 gallons. As the soil and other material are removed from the bed of the reservoir and open channel, a total excavation, estimated at 651,200 cubic yards of material, will be required. The amount

already excavated is 239,000 cubic yards, or 37 per cent. of the whole.

The dam at the outlet of the reservoir, which has a length of 900 feet, and is built with a concrete core wall and earth embankments, has been about one-half completed.

The large amount of earth excavated, which has to be disposed of in embankments and mounds, has been deposited under the direction of Olmsted Brothers, landscape architects.

A careful inspection has been made of the various camps in which the laborers have their lodgings, and a fair sanitary condition has been maintained.

The various contracts require the completion of the work by the end of the coming summer, and it is believed that it will be possible to put the aqueduct into use at some time during the latter part of the year.

When completed, the aqueduct will have a total length of 13.44 miles, and a capacity for carrying 300,000,000 gallons of water per day.

The total amount expended for all purposes on account of the construction of the aqueduct and reservoir, including the pipe lines extending from the terminal chamber, up to January 1, 1903, has been $1,985,550.32, of which $1,562,946.76 have been expended during the past year. It was estimated, before the work was begun, that the entire cost of the aqueduct proper and reservoir, including the pipe lines, would be $5,000,000.

(4) Forbes Hill Reservoir and Standpipe at Quincy.

The masonry tower, which surrounds the steel standpipe erected in connection with the reservoir at Forbes Hill in Quincy, was completed in July of last year, at a cost, exclusive of engineering, of $26,120. The tower is circular, built of uncoursed granite masonry from the Quincy quarries, with cut-stone trimmings, and surmounted by battlements. It has an outside diameter, in general, of 43 feet, an inside diameter of 36½ feet, and a height of 77 feet to the continuous line of the embattlements. At the top of the tower there is a granolithic roof, 260 feet above Boston City Base, which is accessible to the public. The top of the tower, which is reached by a staircase between the standpipe and surrounding masonry tower, affords an extensive view of the surrounding country.

WESTON AQUEDUCT — 7½-FOOT STEEL PIPE AT HAPPY HOLLOW SIPHON IN WAYLAND.

(5) Bear Hill Reservoir.

The Bear Hill Reservoir, which is situated about one-half of a mile west from Spot Pond, and which has been built in order to furnish water to the town of Stoneham at a greater pressure than would be supplied by the Fells Reservoir, was completed in June of the past year. The reservoir was constructed in a depression on the rocky ridge which forms the summit of Bear Hill. The dams were built at each end of the depression, of Portland cement concrete, supported by embankments of earth and loose rock. The earth and rock in the site of the reservoir were excavated to a maximum depth of about 15 feet. The reservoir has an area of about three-quarters of an acre, has a capacity of 2,450,000 gallons, and has an elevation, when full, of 300 feet above the Boston City Base. The superstructure of the small gate chamber will be built during the coming season.

The cost of the construction of the reservoir was $28,411.40.

(6) Pipe Laying.

The second pipe line to connect the Chestnut Hill pumping station and Spot Pond has been finished by the laying of 3.06 miles of 48-inch and 60-inch pipe, in Medford, from a point near Tufts College to Spot Pond. The line, as far as the southerly boundary of the Middlesex Fells, is of 48-inch pipes, and thence to Spot Pond is of 60-inch pipes. The pipes are laid through Wright's Pond in Medford, which was emptied in order to facilitate the work. For the larger part of the distance between Wright's Pond and Spot Pond it was necessary to cut a trench, principally through rock, at a depth of from 15 to 22 feet. The trench, however, has been cut wide enough to admit in the future another line of pipes.

There are now two separate main pipe lines connecting Chestnut Hill Reservoir and Spot Pond.

It has been necessary, in order to supply the higher portions of Milton with water at a sufficient pressure, to lay a 12-inch pipe line in Hyde Park from the West Roxbury boundary line to and across the Neponset River and to the Milton boundary line. By this pipe line the high service of Milton will be supplied from the pumping station and standpipe of the West Roxbury high service. The length of this line is about 8,800 feet.

Several pipe lines will ultimately be required for conveying the water, from the terminus of the Weston Aqueduct in Weston, into the different portions of the Metropolitan Water District.

Contracts have been made and the work has been well advanced for the laying of a line of 60-inch cast-iron pipes from the terminal chamber, across the Charles River, an entire length of 1,920 feet. Under the river, however, for a distance of about 350 feet, three 60-inch lines were laid at the same time, two of these being intended for use in the future, as they may be demanded.

A line of 48-inch pipes is in process of being laid from the terminus of the 60-inch pipe in Newton, through the Commonwealth Avenue Boulevard, and through various other streets and private lands, to Commonwealth Avenue in Brighton, and thence, in the southerly roadway, to the easterly end of Chestnut Hill Reservoir, where it will be connected with the mains leading toward the central portions of Boston. About 26,779 feet of this line have been laid during the past year. The work has been more costly than estimated, on account of the necessity of so modifying the plans as to avoid future interference with the surface drainage system of the city of Newton, as well as the necessity of a large amount of rock excavation. The work of resurfacing the roadways in the Newton Boulevard is done by the street department of the city of Newton, at the expense of the Commonwealth.

(7) Improvement of Spot Pond Brook.

Chapter 112 of the Resolves of the General Court of the year 1902 directed the Metropolitan Water and Sewerage Board to investigate the condition of Spot Pond Brook in Stoneham, Melrose and Malden, to report a plan for such improvements of the brook as should provide for the easy and natural flow to tide water of the water from Doleful Pond and surrounding country, turned into the brook by the Board, and to take into consideration the whole question of the improvement of the brook; also, if such plan for improvement were found feasible and desirable, to recommend a scheme for apportioning the expense of the improvements between the Commonwealth and the towns and cities benefited, and to determine the extent, if any, to which betterments should be imposed upon abutting owners.

The Board caused investigations to be entered upon by its engi-

neers at once upon the passage of the resolve, and public hearings were given.

The Board found that Spot Pond Brook had, by the overflowing of its banks in times of freshets, caused serious damage in the city of Melrose, and more or less injury in the town of Stoneham and the city of Malden; that the drawing of water from Spot Pond, for the water supply of the municipalities of Malden, Melrose and Medford, had tended to decrease the freshet flow of recent years prior to the taking of the pond for the Metropolitan Water Works in the year 1898; that, though the present use of the pond as a distributing reservoir for the Metropolitan Water Works diverts from the brook a considerable portion of the water naturally flowing into the brook, the remaining waters of the watershed, from Doleful Pond and its vicinity, will tend to a certain extent to restore the condition which existed prior to the taking of the water for water supply, and to increase the flow in the brook above that of recent years preceding the year 1898.

It was, however, the opinion of the Board that the larger element in the increase of the flow in times of freshets is the improvement of the watershed draining into the brook, by the cultivation of unimproved lands, the laying out of streets and of surface drains, and the erection of buildings, so that the rain water runs more directly and speedily into the brook.

The Board also found that certain districts, outside the direct line of the brook, must sooner or later find a relief in better drainage.

It therefore appeared to be the duty of the Board to report a plan for improvement, not as a temporary device to alleviate pressing and immediate troubles, but to suggest a more extensive scheme, which should meet the demands in the district affected which seem sure to arise in the near future.

The plan, prepared by the engineers of the Board and presented to the Legislature, proposes the laying of a 20-inch pipe from the present outlet, in the town of Stoneham, of the water from Doleful Pond and the surrounding country, which now finds its way into the brook, to a point in Melrose near Whittier Street, and near the place where the brook crosses Wyoming Avenue; then to build a new covered conduit, which shall receive the waters from this pipe and also from the brook at this point, and convey them to a point which is near the Wyoming railroad station, and also near the junc-

tion of Ell Pond Brook with Spot Pond Brook; thence to construct, in general along the present line of the brook to Winter Street in Malden, a wide channel with flat slopes to provide for the freshet flows, and a narrower central channel to carry the ordinary flow. In Malden it is proposed to build larger or additional culverts in the highways, and to widen the brook, as far as Mountain Avenue, sufficiently to carry the freshet flows; and thence to construct a separate covered conduit, through Mountain and Linden avenues and through private property, beyond Pleasant Street, to a point at tide water in the brook near the present location of the Malden Electric Company's plant. It is proposed to utilize this covered conduit for the overflow caused by freshets, and to permit the ordinary flow of the brook to continue in the present channel below Mountain Avenue. The plan contemplates the deepening of the channel of the brook for the entire distance between Whittier Street in Melrose and Mountain Avenue in Malden, so as to enable the city of Melrose to provide for the drainage of the low lands along the line of the brook, and also, in like manner, both to improve the low lands along Ell Pond Brook, and to construct a system of drainage which will improve more distant lands not directly connected with Spot Pond Brook. The diversion of the freshet flow at Mountain Avenue in Malden will relieve the more thickly settled and business portions of that city from a pending present danger, and from troubles which must arise from an increasing flow of the brook.

Inasmuch as the proper apportionment of the expenses of the improvement seem to involve the prior solution of some difficult practical and legal problems, and the determination of the present rights enjoyed and of the respective liabilities as to the maintenance of the brook, the Board advised that, if the plan for the improvement of the brook should be approved, the question of apportioning the expenses upon the parties benefited should be referred to the Supreme Judicial Court, with power to determine the legal questions involved, and, by commissioners or otherwise, to make a proper apportionment of the expense incurred, and to determine what abutting owners, if any, would receive benefits, and the amount of the betterments which should be imposed.

This report was transmitted to the Legislature on January 14, 1903.

(8) Police Protection.

Police protection has been afforded, in accordance with the requirements of the Metropolitan Water Act, in places where active construction has been carried on. The police officers have been appointed by the various towns in which their services have been required, and they have been subject to the town authorities in the performance of their duties, but they have been paid for their services by the Board.

For the Wachusett Reservoir district there have been employed 13 officers in the town of Clinton, 5 officers (reduced to 4 in October) in the town of Boylston, 1 of whom is mounted, 3 in the town of West Boylston, and 1 mounted officer in Sterling. The special police officers appointed in the town of Clinton have also been appointed special officers in the town of Boylston. The Boylston officers have been appointed special officers in the towns of Clinton and West Boylston. The West Boylston officers have been made special officers in the town of Boylston. The Sterling officer has been made a special officer in the towns of Boylston and West Boylston.

Along the line of the Weston Aqueduct, 6 police officers have been employed in Framingham, 5 in Wayland and 5 in Weston. In Newton, 2 officers have also been paid by the Board.

(9) Purchases and Takings of Land.

Substantially all the land required for the Wachusett Reservoir has now been either purchased or taken, and in nearly all cases both purchases and takings have been made. Considerable additional purchases were made during the past year, on account of the improvements to be made in Oakdale by reason of the relocation of highways caused by the relocation of the Central Massachusetts Railroad.

Tákings of lands in Berlin and Clinton have been made for the relocation of the railroad. Some takings have also been made in Framingham, Wayland and Weston, in order to complete the acquisition of the lands required for the Weston Reservoir and Aqueduct.

Several takings have been made, both through private land and private ways, for the laying of the pipe lines in Newton, Medford and Hyde Park, and a small amount of land has been taken in Stoneham for the completion of the Spot Pond improvement.

The takings of real estate for the Metropolitan Water Works during the year have numbered 15, affecting an area of 286.199 acres; 271.426 acres were taken in fee, and easements and other rights were taken in 14.773 acres.

List of Takings for Metropolitan Water Works for the Year 1902.

No.	LOCATION AND DESCRIPTION.	Former Owners.	Recorded.	Purpose of Taking.
			1902.	
85	Weston (both sides of Ash Street and southwesterly and westerly from Newton Street). Area, 237.10 acres in fee.	Marshall L. Upham *et al.*	Feb. 12.	Weston Reservoir and Aqueduct.
86	Medford (from Governor Brooks' Lane northeasterly to Border Road in Middlesex Fells Reservation). Area, easements in 0.589 acre; temporary rights to occupy 0.880 acre.	Harry Dutton *et al.*	April 10.	Pipe line.
87	Berlin and Clinton (from railroad bridge in West Berlin westerly to westerly line of new location of Boylston Street in Clinton). Area, 29.74 acres in fee; easements in 0.32 acre.	Jonas H. Carter *et al.*	April 28.	Relocation of Central Massachusetts Railroad, Wachusett Reservoir.
88	West Boylston (Prospect Street and northerly side of new highway). Area, 0.046 acre in fee; easements in 0.058 acre.	George W. Reed.	May 6.	Highway, Wachusett Reservoir.
89	Framingham (on Sudbury River). Area, 0.55 acre in fee.	Katherine S. Cameron.	May 9.	Weston Aqueduct.
90	Newton (from Kenrick Street southerly through Magnolia Avenue and land of George A. Ward to and through old location of Cochituate Aqueduct). Area, easements in 3.360 acres.	George A. Ward *et al.*	May 28.	Pipe line.
91	Medford (from Elm and Forest streets northerly across Wright's Pond to land of the Commonwealth). Area, easements in 5.447 acres.	City of Medford.	June 2.	Pipe line.
92	Hyde Park (from Vose Avenue westerly across Erie Street and New York, New Haven & Hartford Railroad and into Neponset River to park land of Commonwealth). Area, easements in 0.072 acre.	New York, New Haven & Hartford Railroad, Midland Division, and Erie Street.	June 4.	Pipe line.
93	Newton (on southwesterly side of Commonwealth Avenue, northwesterly from Rowe Street). Area, easements in 0.194 acre.	Boston & Albany Railroad Company, leased to New York Central & Hudson River Railroad Company.	June 4.	Pipe line.
94	Medford (in and adjoining Governor Brooks' Lane, from Governor's Avenue and Hall Road northerly to strip described above in No. 86). Area, easements in 0.517 acre; temporary rights to occupy 0.750 acre.	Harry Dutton *et al.*	June 24.	Pipe line.
95	Weston (between Loring and River streets and easterly from River Street to Charles River Reservation). Area, 0.627 acre in fee.	Elmer L. Walker and Marion Preston.	Aug. 5.	Pipe line.
96	Stoneham (westerly side of Woodland Road, near site of Langwood Hotel). Area, 1.153 acres in fee.	Trustees Langwood Park Land Company, *et al.*	Aug. 18.	Spot Pond Improvement.
97	Wayland (from Happy Hollow Road westerly about 2,100 feet to a brook). Area, easements in 1.815 acres.	Thomas Irving and Anthony Irving.	Sept. 13.	Weston Aqueduct.
98	Newton (from Magnolia Avenue through land of George A. Ward *et al.* to and adjoining old location of Cochituate Aqueduct, all adjoining part of strip described above in No. 90). Area, temporary rights to occupy 0.770 acre.	George A. Ward *et al.*	Sept. 29.	Pipe line.

List of Takings for Metropolitan Water Works for the Year 1902 — Concluded.

No.	LOCATION AND DESCRIPTION	Former Owners.	Recorded.	Purpose of Taking.
99	West Boylston (easterly side of North Main Street and southeasterly side of Waushacum Street). Area, 2.21 acres in fee.	Mary S. Mason.	1902. Oct. 18.	Wachusett Reservoir.

Settlement has been effected with the owners of all the land taken or purchased by the Board for the Metropolitan Water Works since the beginning of operations, aside from the works of the cities of Malden, Medford and Melrose, except for 604.08 acres, and in nearly all cases affecting private lands purchases have preceded the takings. Of the lands taken for the Wachusett Aqueduct, the time for bringing suits for two parcels, containing 5.08 acres, has expired. Of the lands taken for the Wachusett Reservoir, the time for bringing suits for four parcels, containing 27.662 acres, has expired.

Settlements under purchases and takings, for all purposes of the Water Works, have been effected in the past year in 65 cases, and for an aggregate of 310.44 acres, with the buildings thereon. The sums paid in these settlements have amounted to $181,586.24. In only 8 of these cases have the settlements been results of suits at law, and the total amount paid in the court settlements has been $23,575.58.

Since the beginning of operations upon the Metropolitan Water Works, the number of settlements of this kind effected for the purposes of the Water Works has amounted to 720; and under them the Board has acquired rights, in fee or in easement, in 11,186.28 acres, or 17.48 square miles, for which an aggregate of $3,637,702.29 has been paid. Only 17 of these cases have been settled by suits at law, and the total amount paid under judgments of the court has been $56,328.62, or less than 2 per cent. of the whole.

These purchases and takings include lands taken in fee, with the buildings thereon, and water and other rights connected therewith, and lands in which easements and other rights are taken; but they do not include settlements for diversion of water, depreciation and other damages connected with lands not acquired, and in which no fee or easement has been taken.

Summary of Land Settlements for Water Works to December 31, 1902.

LOCATION.	For the Year 1902. Area in Acres.	Number of Settlements.	Payments.	From Beginning of Work. Area in Acres.	Number of Settlements.	Payments.
*Wachusett Reservoir.**						
Clinton,	37.31	33	$139,292 12	1,221.63	368	$2,674,632 30
Boylston,	10.42			3,572.35		
West Boylston,	130.96			1,607.92		
Sterling,	33.00			694.91		
Lancaster,	-			69.97		
Holden,	-			167.00		
Total,	211.69	33	$139,292 12	7,333.78	368	$2,674,632 30
Wachusett Aqueduct.						
Berlin,	-	3	$3,275 00	46.51	64	$72,487 40
Boylston,	-			.38		
Northborough,	13.51			96.07		
Southborough,	5.00			82.31		
Marlborough,	.46			51.08		
Clinton,	-			13.51		
Total,	18.97	3	$3,275 00	289.86	64	$72,487 40
Sudbury Reservoir.†						
Southborough,	-	-	-	1,995.58	150	$658,318 75
Marlborough,	-			750.98		
Total,	-	-	-	2,746.56	150	$658,318 75
Improving Sudbury Water-shed.						
Northborough,	4.34	2	$1,250 00	131.35	34	$12,949 10
Southborough,	-			2.66		
Westborough,	-			202.48		
Ashland,	-			.63		
Marlborough,	-			.74		
Total,	4.34	2	$1,250 00	337.86	34	$12,949 10
Clinton Sewerage System.						
Clinton,	.67	5	$10,042 90	5.32	35	$30,544 40
Lancaster,	26.99			108.72		
Total,	27.66	5	$10,042 90	114.04	35	$30,544 40
Weston Aqueduct.						
Weston,	29.23	18	$21,699 22	251.30	41	$79,759 46
Framingham,	7.69			70.04		
Wayland,	7.05			8.65		
Total,	43.97	18	$21,699 22	329.99	41	$79,759 46
Distribution System.						
Boston,	-	3	$4,427 00	.70	27	$107,410 88
Brookline,	-			.05		
Arlington,	-			1.80		
Malden,	-			.16		
Medford,	-			2.39		
Newton,	-			.06		
Quincy,	-			5.23		
Stoneham,	.86			20.85		
Total,	.86	3	$4,427 00	31.24	27	$107,410 88
Improving Lake Cochituate.						
Natick,	2.95	1	$1,600 00	2.95	1	$1,600 00
Total,	2.95	1	$1,600 00	2.95	1	$1,600 00
Aggregates,	310.44	65	$181,586 24	11,186.28	720	$3,637,702 29

* Including payments on account of St. John's Catholic Cemetery.

† Including settlements made by city of Boston.

(10) Claims and Settlements for Loss of Business.

Additional claims for injury to business, caused by the carrying out of the Metropolitan Water Act in the towns of West Boylston and Boylston and portions of the towns of Sterling and Clinton, have been filed during the year ending December 31, 1902, to the number of 6. Settlements of such claims have been effected during the year in 30 cases, under which the sum of $36,250 has been paid; 2 claims have been reconsidered, and settlements thereon effected. Of these claims, 6 have been settled in court. The number of claims of this class settled since the beginning of the water works is 237, and the total sum paid on account of such claims is $88,517.

(11) Claims and Settlements for Loss of Employment.

During the year ending December 31, 1902, 16 claims for damages for loss of employment by residents of West Boylston have been filed. Settlements have been made in 17 cases, the amount paid being $3,387.75. During the year, 7 claims have been disallowed; and votes previously passed disallowing 2 claims were afterwards reconsidered, and settlements made thereunder. The whole number of settlements effected is 469. The total amount paid on account of these claims is $85,559.16.

(12) Claims and Settlements for Depreciation of Real Estate.

Settlements in 83 cases of injury to real estate in the towns of Sterling and West Boylston have been made during the year ending December 31, 1902, and the sum of $104,259.40 has been paid. Of these claims, 29 have been settled in the courts. The total number of claims of this class settled to December 31, 1902, has been 166, and the total amount paid thereon has been $143,779.40.

In all the remaining cases in West Boylston and Sterling, in which application has been made for damages by owners of such real estate, offers of settlement have been made by the Board.

In the Act providing for the payment of damages for depreciation in the value of real estate were included that part of the town of Boylston that is situated on the northerly side of the proposed reservoir, and that part of the town of Clinton on either side of River

and Grove streets for a certain distance below the dam. The estates affected in Boylston have all become the property of the Commonwealth; and suits have been brought for the recovery of damages by the owners of the estates in that part of the town of Clinton named in the Act.

III. WATER WORKS — MAINTENANCE.

(1) Operation of Works.

The cities and towns supplied with water during the entire year were Boston, Chelsea, Everett, Malden, Medford, Melrose, Quincy, Somerville, Arlington, Belmont, Nahant, Revere, Stoneham, Swampscott, Watertown and Winthrop. The town of Milton was supplied with water after February 28, 1902, through the Milton Water Company, by an arrangement made with that company. A small portion of the town of Saugus was supplied with water in accordance with authority given by the Legislature of the year 1902, through the Revere Water Company. The total population of the cities and towns thus supplied with water in the year 1902 was, as estimated, 874,200.

Water to the extent of 4,320,000 gallons was supplied to the town of Lexington, on account of an exigency which arose in the water supply of that town. The city of Newton and the town of Hyde Park were not supplied with water during the year, inasmuch as, in the opinion of the Board, these municipalities had not reached the safe capacity of their present sources of supply in a dry year.

The city of Medford supplied from its local sources 9,830,000 gallons. The Milton Water Company supplied to the town of Milton, previous to February 28, and subsequently, for the high service in that town, 20,190,000 gallons.

All the rest of the water supplied during the year to the cities and towns of the Metropolitan Water District, amounting to 39,122,640,000 gallons, was furnished by the Metropolitan Water Works.

(2) Storage Reservoirs.

The total nominal capacities of all the storage reservoirs is 15,858,500,000 gallons, as follows: —

	Gallons.
Lake Cochituate, including Dudley Pond,	2,242,400,000
Sudbury Reservoir,	7,253,500,000
Framingham Reservoir No. 1,	287,500,000
Framingham Reservoir No. 2,	529,900,000
Framingham Reservoir No. 3,	1,183,500,000
Ashland Reservoir,	1,416,400,000
Hopkinton Reservoir,	1,520,900,000
Whitehall Reservoir,	1,256,900,000
Farm Pond,	167,500,000
Total,	15,858,500,000

As a matter of fact, however, the amount of water in storage in these reservoirs was, at the maximum period during the year, 16,129,500,000 gallons.

The Wachusett Reservoir when completed will alone have a capacity of upwards of 63,000,000,000 gallons.

The reservoirs at the beginning of the year were as nearly full as it is desirable to keep them during the winter months. The early rains caused them to be entirely filled in May, and they so remained until June. There was a steady decrease in the amount in storage until the end of September, when the reservoirs began again to fill; and at the end of the year the amount of water in storage in these reservoirs was 11,716,100,000 gallons. They were for the season in a generally satisfactory condition.

The various sources of supply furnished the District an average of 107,268,000 gallons per day. An average of 66,127,000 gallons per day was conveyed from the South Branch of the Nashua River, through the Wachusett Aqueduct, into the Sudbury Reservoir; and the various reservoirs of the Sudbury system, with this addition, supplied through the Sudbury Aqueduct to the Metropolitan District an average of 95,645,000 gallons per day. An average of 12,165,000 gallons per day was drawn from Lake Cochituate and supplied to the District through the Cochituate Aqueduct.

Water is drawn from the less satisfactory sources only when required by the larger consumption of water in the District.

(3) Distributing Reservoirs.

The distributing reservoirs, which are maintained by the Board not only for the purpose of distributing the water supply, but also for giving a greater protection to the District, by reason of the large amount of water stored within the District, in case of accident to the aqueducts, have a total capacity of 2,181,232,000 gallons, as follows: —

	Gallons.
Spot Pond,	1,791,700,000
Chestnut Hill Reservoir,	300,000,000
Fells Reservoir,	41,400,000
Mystic Reservoir,	26,200,000
Waban Hill Reservoir in Newton,	13,500,000
Forbes Hill Reservoir in Quincy,	5,100,000
Forbes Hill Standpipe,	330,000
Arlington Standpipe,	550,000
Bear Hill Reservoir,	2,450,000
Total,	2,181,230,000

The Bear Hill Reservoir has been added during the year.

The considerable grounds around the Chestnut Hill Reservoir, which belong to the Commonwealth and are under the custody of the Board, constitute, in fact, a part of the park system of the city of Boston, and are much resorted to during the summer, especially on Sundays and holidays. Considerable expense is therefore required to keep these grounds in good order, and a policing force is required for their care and protection at times when visited in large numbers by the public.

The Forbes Hill tower is also open to the public, for whom it has proved most attractive for sight-seeing, and the grounds surrounding the reservoir are also resorted to as a park.

Spot Pond, as well as the smaller Fells and Bear Hill reservoirs, constitutes a portion of the Middlesex Fells, and in reality adds an important attraction to this region. The proper care of these grounds also adds considerable expense to the cost of maintenance.

(4) Aqueducts.

The Wachusett Aqueduct has been in use 309 days during the year. During the remainder of the time the water has been shut off for cleaning the aqueduct, and also at periods during the winter and spring freshets on account of the turbidity of the river, which made the water unsatisfactory as a part of the water supply. The aqueduct has continued in excellent condition.

The Sudbury Aqueduct was in constant service during the year except during the days when it was shut off for cleaning. Although in the preceding year it was running nearly full, an excess of more than 5,317,000 gallons has been carried daily during the last year. The aqueduct has continued in good condition, notwithstanding such use; but it has been deemed necessary to guard it carefully against any menace or interference, inasmuch as the constant running of the aqueduct at substantially its full capacity was absolutely necessary for the demands of the District.

The Cochituate Aqueduct has been used for 259 days, and a somewhat less amount of water has been carried than in the preceding year. The improvements in progress in the Pegan Brook Meadow diminished to a certain extent the available supply from Lake Cochituate.

(5) Pumping Stations.

The two pumping stations at the Chestnut Hill Reservoir have pumped all of the water which has been supplied to the Metropolitan District during the last year, with the exception of the very small quantity supplied by the city of Medford and the Milton Water Company, and from the watershed of Spot Pond. At the high-service station the water is pumped for the high-service district of Boston, the city of Quincy, the towns of Watertown and Belmont and the greater part of the town of Milton. Water is pumped at the low-service station not only for the low-service districts, but to Spot Pond, from which are supplied, by pumping, the northern high-service district, and also the Fells and the Bear Hill reservoirs.

The water is again pumped at the Arlington pumping station for the extra high service in that town, and at the West Roxbury pumping station for the Roxbury extra high service and for a portion of the town of Milton.

The various pumping stations, with their respective capacities for pumping and the quantities of water pumped by them, are as follows: —

NAME.	Total Capacity of Pumps (Gallons per Day).	Average Number of Gallons pumped per Day.
Chestnut Hill, high service,	66,000,000	29,852,000
Chestnut Hill, low service,	105,000,000	76,553,000
Spot Pond,	30,000,000	7,997,000
Arlington,	1,500,000	315,000
West Roxbury,	2,000,000	352,000

The daily pumping capacity of all the stations is 204,500,000 gallons, and the average number of gallons pumped per day during the year was 115,069,000. The total number of gallons pumped during the year was 42,000,400,000.

The necessity of supplying new boilers at the Chestnut Hill high-service station, and the great increase in the cost of fuel, which is nearly one-half of the total expense of pumping, added considerably to what otherwise would have been the cost. Notwithstanding these additional expenses, the cost of pumping per million gallons during the year was but $2.50, — a reduction of 2 cents from the cost per million gallons in the preceding year. The cost of pumping in the year 1897 was $9.64 per million gallons. The results obtained in the larger stations show the great saving which has been obtained by the concentration of pumping stations, and by the use of pumping engines having a large capacity.

(6) Pipe Lines and Pipe Yards.

The Glenwood pipe yard for the northern district, and the Chestnut Hill pipe yard for the southern district, are maintained with equipments for the care and repair of the pipe lines. A considerable emergency and repair force is kept at both the yards, ready to make any immediate necessary repairs which may be required. These forces have charge of the 82.9 miles of pipe lines which are now owned and operated by the Board; they are also able to make various small additions, and to make the ordinary changes which are required from time to time.

During the past year the maintenance force has taken up and relaid a considerable length of pipe required on account of the abolition of grade crossings on Winthrop Avenue in Revere on the Boston & Maine Railroad. Pipes were relaid at the Middlesex Avenue crossing of the Mystic River between Somerville and Medford, on account of the action of the Metropolitan Park Commission in building a new bridge crossing the river. Considerable work has also been required on account of the construction of the Metropolitan sewer in Adams Street in Milton and Quincy, in close proximity to the 24-inch water main supplying the city of Quincy.

(7) Clinton Sewerage and Filtration Works.

In the operation of the Clinton Sewerage Works, the amount of sewage pumped and deposited upon the filter-beds has decreased from 838,000 gallons per day, the amount in the preceding year, to 786,000 gallons per day. This decrease of about 50,000 gallons per day was largely brought about by the reconstruction of a piece of sewer in the town which was found to be causing a great leakage. The cost per million gallons pumped has been $8.34, as against $8.24, the cost in the preceding year. The cost of filtration per million gallons has been $8.29. The total cost of the operation of the pumping station and filter-beds has been $4,735.43.

(8) Sanitary Inspection and Regulations.

Beside the three medical inspectors who have been under the supervision of the engineers having charge of the works of construction in the Wachusett Reservoir and along the Weston Aqueduct, the Sudbury, Cochituate and Wachusett watersheds have been under the sanitary inspection of William W. Locke, C.E., sanitary inspector, and two assistants.

The inspectors have kept a constant oversight of the watersheds. There have been but few cases of contagious diseases among the residents of the watersheds, and those which have occurred have been cared for by the local authorities when called to their notice by the inspectors of the Board.

Accurate statistics have been obtained relative to the condition of the 118 square miles constituting the Wachusett watershed. The permanent population of this watershed numbers 5,764, — a popula-

tion of 49 per square mile. There is in addition a summer population of 2,384. The horses, cattle, sheep and swine number 6,781, and the poultry 38,062. The total number of premises is 1,746, of which 1,298 are occupied permanently, 258 are occupied in the summer, and 127 are vacant or deserted. These statistics do not include persons employed in connection with the construction of the Wachusett Dam and Reservoir.

In the Wachusett watershed 1,495 premises have been specially inspected, and all but 176 were left in a satisfactory condition at the end of the year.

In the Sudbury and Cochituate watersheds 918 premises were specially inspected, of which all but 154 were left in a satisfactory condition at the end of the year. In these watersheds 136 cases were remedied by sewer connections, 7 were otherwise remedied, and 17 were partially remedied, the cesspools in 130 of the cases being entirely abandoned.

In general the local boards of health have zealously co-operated with the inspectors.

In one case of mill pollution the proprietor has refused either to remedy the pollution or to allow the Board to do so, and legal proceedings have been begun to abate the trouble.

Some attempts have been made by the authorities of the city of Marlborough to improve the condition of Marlborough Brook, which empties into the head of the Sudbury Reservoir, and to prevent the overflow of the sewage, in times of considerable rains, from the sewers into the brook. The attempts made have been entirely inadequate, and the Board has been compelled to request the Attorney-General to institute proceedings for the prevention of this serious pollution of the water supply.

No additional ditches for the drainage of swamps have been built during the year, and no material repairs for those previously built have been required. A considerable force has, however, been required for keeping in good condition the 15.55 miles of drainage ditches tributary to the open channel of the Wachusett Aqueduct. The improvement made in the color of the water has been maintained.

On August 28 the Board adopted the following special regulation under Rule 14 of the rules of the State Board of Health: —

Permission is given, until further order, to fish in the waters of the Quinepoxet and Stillwater rivers, and ponds tributary thereto, subject to the following limitations and conditions : —

a. No fish, food or other matter tending to pollute the water shall be thrown into the water or left upon the shores.

b. No tin cans or bait boxes shall be thrown into the water or left upon the shores.

c. No person shall build any fire upon the shores or other land belonging to the Commonwealth.

d. In case fishing is carried on through the ice, no person shall throw or leave upon the ice any fish, bait, food or other matter tending to pollute the water.

IV. WATER WORKS — FINANCIAL STATEMENT.

(1) Metropolitan Water Loan, Receipts and Assessments.

The appropriations for the construction and acquisition of the Metropolitan Water Works, the receipts which are added to these appropriations, the expenditures for the construction and acquisition of works, and the balance available on January 1, 1903, have been as follows : —

Appropriation under chapter 488 of the Acts of 1895,	$27,000,000 00
Appropriation under chapter 453 of the Acts of 1901,	13,000,000 00
	$40,000,000 00
Proceeds from the sales of property applicable to the construction and acquisition of works (of which $27,084.18 is for the year 1902),	58,197 76
	$40,058,197 76
Amount approved by the Metropolitan Water Board and the Metropolitan Water and Sewerage Board for payments to December 31, 1902 (of which $3,657,389.30 is for the year 1902),	33,089,721 33
Balance January 1, 1903,	$6,968,476 43

The Treasurer of the Commonwealth, under the authority given him to issue from time to time, on the request of the Board, negotiable bonds to an amount not exceeding $40,000,000, to be designated the "Metropolitan Water Loan," has sold bonds as follows : —

DATE.	Bonds sold.	Rate (Per Cent.).	Time (Years).	Price.	Premiums (in Amount).
1895, . . .	$2,225,000	3½	40	$110 67	$237,407 50
1896, . . .	2,775,000	3½	40	110 67	296,092 50
1896, . . .	2,000,000	3½	39	106 76268	135,253 60*
1897, . . .	6,000,000	3½	38½	107 82	469,200 00
1898, . . .	2,000,000	3½	40	113 176	263,520 00
1898, . . .	2,000,000	3½	40	112 877	257,540 00
1899, . . .	3,000,000	3	40	100 64	19,200 00
1900, . . .	1,000,000	3	39	102 78	27,800 00
1901, . . .	3,000,000	3	40	102 78	83,400 00
1901, . . .	100,000	3	40	100 375	375 00
1901, . . .	150,000	3	40	100 10	150 00
1901, . . .	205,000	3	39½	100 25	512 50
1901, . . .	50,000	3	39½	100 25	125 00
1901, . . .	50,000	3	39½	100 50	250 00
1901, . . .	300,000	3	39½	100 10	300 00
1901, . . .	200,000	3	39½	100 25	500 00
1901, . . .	3,100,000	3½	39½	106 71	208,010 00
1901, . . .	1,345,000	3	39½	100 00	-
1901, . . .	1,500,000	3	39½	100 00	-
1902, . . .	3,000,000	3½	40	109 13	273,900 00
1902, . . .	500,000	3½	40	109 13	45,650 00
	$34,500,000				$2,319,186 10

* Including $18,673.60 from readjustment of rate made by the Treasurer in 1897.

The sinking fund established by the Treasurer of the Commonwealth has amounted at the end of each year to sums as follows: —

December 31, 1895, ...	$226,286 05
December 31, 1896, ...	699,860 70
December 31, 1897, ...	954,469 00
December 31, 1898, ...	1,416,374 29
December 31, 1899, ...	1,349,332 97
December 31, 1900, ...	1,573,619 72
December 31, 1901, ...	1,662,426 95
December 31, 1902, ...	2,256,803 81

Allowances for water furnished from their own sources by cities and towns during the year ending May 31, 1902, were made, in accordance with the Metropolitan Water Act, as follows: —

Medford,.	$117 96
Stoneham, ...	1,366 80

After deducting these allowances, the net assessments for the year 1902, made by the Treasurer of the Commonwealth, for the payment of the interest on the bonds issued by the Commonwealth, the sink-

ing fund requirements and the expenses of operation and maintenance of the water works, were as follows: —

Arlington,	$9,272 28	Newton,	$7,498 70
Belmont,	4,673 09	Quincy,	24,379 11
Boston,	1,274,105 31	Revere,	11,030 42
Chelsea,	32,178 83	Somerville,	62,397 89
Everett,	23,931 73	Stoneham,	4,799 38
Hyde Park,	2,187 72	Watertown,	10,862 53
Malden,	33,352 35	Winthrop,	6,905 58
Medford,	19,891 83		
Melrose,	14,434 93		$1,544,596 47
Nahant,	2,694 79		

The comparatively smaller sums assessed upon the city of Newton and the town of Hyde Park were owing to the fact that neither of these municipalities had reached the safe capacity of its sources, and consequently neither had been furnished with water.

The proceeds from the operations of the Board, exclusive of the proceeds from sales of property, have been, according to the provisions of the Water Act, applied to the payment of interest and sinking fund requirements and the maintenance and operation of works, as follows: —

For the year 1902,	$17,195 71

The expenditures for the maintenance and operation of the Metropolitan Water Works have been as follows: —

For the year 1902,	$294,045 14

Sums have been received during the year 1902, under the provisions of the Metropolitan Water Act, for water furnished as follows: —

Swampscott,	$3,000 00
Revere Water Company,	160 00
Framingham Water Company,	312 90
Milton Water Company,	17,301 27
	$20,774 17

At the close of the year, the Treasurer, in accordance with the requirements of the Act, has distributed to the cities and towns of the District, in proportion to the annual assessments theretofore contributed by them, this amount, as follows: —

Arlington,	$41 12	Newton,	$103 36
Belmont,	50 16	Quincy,	358 78
Boston,	17,255 50	Revere,	121 13
Chelsea,	549 94	Somerville,	907 53
Everett,	261 14	Stoneham,	39 77
Hyde Park,	34 29	Watertown,	141 15
Malden,	521 93	Winthrop,	66 16
Medford,	260 97		
Melrose,	232 46		$20,955 21*
Nahant,	9 82		

(2) Expenditures for the Different Works.

The following is a summary of the expenditures made in the various operations for the different works: —

CONSTRUCTION AND ACQUISITION OF WORKS.	For the Year ending December 31, 1902.		From Beginning of Work, and ending December 31, 1902.	
Administration applicable to all parts of the construction and acquisition of the works,		$24,020 55		$198,693 20
Wachusett Dam and Reservoir: —				
Wachusett Dam,	$437,816 41		$897,910 17	
North Dike,	94,701 42		609,748 12	
South Dike,	221 25		5,172 94	
Removal of soil,	493,524 56		1,602,528 64	
Relocation of railroads,	200,084 84		214,914 23	
Roads and bridges,	26,381 25		311,358 68	
Real estate,	169,985 04		2,945,516 26	
Damages, real estate not taken, business and loss of wages,	143,897 15		317,855 56	
Other expenses,	1,606 16	1,568,218 08	4,199 19	6,909,203 79
Improving Wachusett watershed,		1,353 29		16,156 65
Wachusett Aqueduct,		8,390 60		1,787,911 37
Sudbury Reservoir,		331 43		2,922,445 21
Protection of Sudbury supply,		29 51		119,692 37
Improving Sudbury watershed,		1,998 24		90,813 20
Protection of Cochituate supply,		-		9,000 00
Improving Cochituate watershed,		8,783 04		8,783 04
Improving Lake Cochituate,		70,090 35		96,250 73
Pipe lines, Dam No. 3 to Dam No. 1,		-		48,471 48
Pipe line, Rosemary siphon,		-		23,142 98
Weston Aqueduct: —				
Aqueduct,	$1,093,420 31		$1,429,941 44	
Reservoir,	66,092 27		81,107 55	
Supply pipe lines,	377,746 06		384,514 03	
Real estate, taxes and other expenses,	25,688 12	1,562,946 76	89,987 30	1,985,550 32
Amounts carried forward,		$3,246,161 85		$14,216,114 34

* Including $181.04 remaining undistributed last year.

CONSTRUCTION AND ACQUISITION OF WORKS.	For the Year ending December 31, 1902.		From Beginning of Work, and ending December 31, 1902.	
Amounts brought forward,		$3,246,161 85		$14,216,114 34
Distribution system: —				
Low service: —				
Pipe lines and connections,	$264,331 78		$1,731,778 03	
Pumping station, Chestnut Hill,	260 51		459,250 97	
Reservoir, Spot Pond,	2,542 84		578,063 03	
Gate-house and connections, Chestnut Hill Reservoir,	98 33		65,480 88	
Real estate and other expenses,	5,086 88		84,211 61	
Northern high service: —				
Pipe lines and connections,	525 89		439,516 77	
Spot Pond pumping station,	46 81		290,329 35	
Fells Reservoir, Stoneham,	17 08		141,387 94	
Bear Hill Reservoir, Stoneham,	11,463 83		34,793 12	
Real estate and other expenses,	464 20		14,838 05	
Southern high service: —				
Pipe lines and connections,	744 16		503,326 94	
Pumping station, Chestnut Hill,	361 74		242,121 35	
Forbes Hill Reservoir, Quincy,	21,303 11		89,978 48	
Waban Hill Reservoir, Newton,	30 00		61,592 11	
Real estate and other expenses,	3 52		10,226 36	
Northern extra high service,	702 62		13,558 74	
Southern extra high service,	22,036 92		22,417 22	
Meters and connections,	30,657 71		30,657 71	
Improving Spot Pond Brook,	2,606 18		2,606 18	
Glenwood pipe yard,	-		33,100 59	
Chestnut Hill pipe yard,	2 28	363,286 39	11,066 26	4,860,301 69
Diversion of water, south branch of Nashua River,*		25,378 76		1,112,466 65
Acquisition of existing water works: —				
Reimbursement city of Boston, partially constructed Sudbury Reservoir,	-		$1,157,921 59	
To Boston, for works taken Jan. 1, 1898,	-		12,768,948 80	
To Malden (on account), for taking of Spot Pond,	-		25,749 71	
To Newton, for Waban Hill Reservoir,	-		60,000 00	
	-		$14,012,620 10	
Transfers of works acquired and other property to accounts for special works,	-		1,239,497 26	
	-		$12,773,122 84	
Engineering, conveyancing, etc.,	-		24,107 60	12,797,230 44
Pipes, valves, etc., sent to store yard, and not yet transferred to works,		22,562 30		103,608 21
Total for constructing and acquiring of works,		$3,657,389 30		$33,089,721 33

* Of the total expenditures from the beginning of the work, the sum of $134,606.87 is for Clinton sewerage system.

MAINTENANCE AND OPERATION.	For the Year ending December 31, 1902.		From Beginning of Work, and ending December 31, 1902.	
Administration,	. . .	$6,272 03		$38,082 84
General supervision,	. . .	3,040 42		13,527 99
Taxes and other expenses,	. . .	31,479 38		78,959 52
Wachusett Reservoir Department: —				
Sanitary inspection,	$917 84		$957 28	
Buildings,	16 95		586 94	
Reservoir,	293 86		625 03	
		1,228 65		2,169 25
Wachusett Dam and Aqueduct Department: —				
General superintendence,	$852 16		$7,713 59	
Dam and aqueduct,	7,513 46		35,590 74	
Clinton sewerage system: —				
Pumping station,	2,593 62		7,789 17	
Sewers, screens and filter-beds,	2,590 99		7,386 85	
Sanitary inspection,	363 35		1,632 69	
		13,913 58		60,113 04
Sudbury Department: —				
General superintendence,	$4,761 32		$29,976 05	
Superintendence, Framingham office,	5,602 96		28,778 35	
Sudbury Reservoir,	6,631 41		36,093 96	
Ashland Reservoir,	2,254 04		8,856 54	
Hopkinton Reservoir,	1,762 77		10,949 44	
Whitehall Reservoir,	245 31		1,658 78	
Framingham Reservoirs, 1, 2 and 3,	4,827 50		24,552 88	
Lake Cochituate,	2,805 70		14,553 54	
Marlborough Brook filters,	3,909 14		10,544 37	
Pegan filters,	5,983 42		17,323 87	
Sudbury and Cochituate watersheds,	384 10		2,115 82	
Sanitary inspection,	2,354 31		12,027 76	
Sudbury and Cochituate Aqueducts,	20,189 82		90,441 72	
Chestnut Hill Reservoir,	12,831 79		56,148 66	
Biological laboratory,	2,892 13		16,759 53	
		77,435 72		360,781 27
Distribution Department: —				
Superintendence,	$8,997 79		$36,349 70	
Arlington pumping station, pumping service,	4,694 57		11,432 31	
Chestnut Hill high-service pumping station, pumping service,	42,103 02		217,877 33	
Chestnut Hill low-service pumping station, pumping service,	35,408 34		94,477 51	
Spot Pond pumping station, pumping service,	12,172 67		38,876 80	
West Roxbury pumping station, pumping service,	5,855 74		24,952 87	
Temporary pumping stations,	-		52,979 06	
Arlington standpipe,	25 00		418 93	
Fells Reservoir,	947 21		3,854 46	
Mystic Lake, conduit and pumping station,	3,076 52		17,386 63	
Mystic Reservoir,	1,305 92		10,392 12	
Bear Hill Reservoir,	315 59		315 59	
Forbes Hill Reservoir,	1,762 30		1,920 34	
Amounts carried forward,	$116,664 67	$133,369 78	$511,233 65	$553,633 91

MAINTENANCE AND OPERATION.	For the Year ending December 31, 1902.		From Beginning of Work, and ending December 31, 1902.	
Amounts brought forward,	$116,664 67	$133,369 78	$511,233 65	$553,633 91
Distribution Department — *Con.*				
Spot Pond,	4,507 58		13,555 17	
Buildings at Spot Pond,	924 28		924 28	
Waban Hill Reservoir,	506 56		3,957 58	
Pipe lines: —				
Low service,	10,447 88		92,937 59	
Northern high service,	5,557 97		23,101 09	
Southern high service,	2,524 12		13,386 27	
Buildings at Chestnut Hill,	3,153 48		7,902 49	
Chestnut Hill pipe yard,	1,656 24		3,139 00	
Glenwood pipe yard and buildings,	5,654 01		16,620 83	
Stables,	6,270 10		22,043 54	
Waste prevention,	2,808 47	160,675 36	2,898 61	711,700 10
Total for maintaining and operating works,		$294,045 14		$1,265,334 01

(3) Detailed Financial Statement.

The Board herewith presents, in accordance with the Metropolitan Water Act, an abstract of the expenditures and disbursements, receipts, assets and liabilities for the year 1902.

(a) *Expenditures and Disbursements.*

The total amount of the expenditures and disbursements on account of construction and acquisition of works for the year beginning January 1, 1902, and ending December 31, 1902, is $3,657,389.30, and the total amount from the time of the organization of the Board, July 19, 1895, to December 31, 1902, is $33,089,721.33.

For maintenance and operation the expenditures for the year have been $294,045.14, and from the beginning of the work $1,265,334.01.

The salaries of the commissioners, and other expenses of administration, have been apportioned to the construction of the works and to the maintenance and operation of the same, and appear under each of those headings.

The following is a division of the expenditures according to their general character: —

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1902.		From Beginning of Work, and ending December 31, 1902.	
I. CONSTRUCTION OF WORKS, AND ACQUISITION BY PURCHASE OR TAKING.				
Administration.				
Commissioners,	$8,166 66		$86,976 93	
Secretary and auditor,	4,170 82		37,491 72	
Clerks and stenographers,	7,571 31		38,027 41	
Legal services,	-		2,359 00	
Travelling,	273 06		2,272 21	
Stationery and printing,	854 23		6,323 89	
Postage, express and telegrams,	373 96		2,043 11	
Furniture and fixtures,	180 94		3,974 69	
Alterations and repairs of buildings,	51 05		5,723 08	
Telephone, lighting, heating, water and care of building,	1,029 62		7,596 41	
Rent and taxes, main office,	930 40		2,312 40	
Miscellaneous expenses,	418 50	$24,020 55	3,592 35	$198,693 20
Engineering.				
Chief engineer and department engineers,	$23,821 59		$156,068 79	
Principal assistant engineers,	15,081 53		110,606 41	
Engineering assistants,	112,837 95		781,812 06	
Consulting engineers,	-		23,187 07	
Inspectors,	48,652 64		211,413 46	
Architects,	390 00		26,260 47	
Railroad and street car travel,	2,972 12		23,942 66	
Wagon hire,	6,737 01		32,508 22	
Stationery and printing,	2,860 28		21,737 27	
Postage, express and telegrams,	826 22		6,360 17	
Engineering and drafting instruments and tools,	646 61		18,875 13	
Engineering and drafting supplies,	2,012 70		21,604 86	
Books, maps and photographic supplies,	436 49		5,271 33	
Furniture and fixtures,	563 90		14,804 48	
Alterations and repairs of building, — main office,	390 14		13,115 70	
Alterations and repairs of building, — sub-offices,	135 11		2,736 75	
Telephone, lighting, heating, water and care of building, — main office,	2,755 61		13,882 29	
Telephone, lighting, heating, water and care of building, — sub-offices,	1,777 63		12,594 82	
Rent and taxes, — main office,	2,831 20		6,705 55	
Rent of sub-offices and other buildings,	554 00		3,707 74	
Field offices and sheds,	168 84		1,236 54	
Clinton office building,	-		9,866 87	
Unclassified supplies,	1,370 22		7,126 94	
Miscellaneous expenses,	357 36	228,179 15	7,661 77	1,533,087 35
Amounts carried forward,		$252,199 70		$1,731,780 55

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1902.		From Beginning of Work, and ending December 31, 1902.	
Amounts brought forward, . . .	. . .	$252,199 70		$1,731,780 55
Construction.				
Preliminary work (borings, test pits and other investigations): —				
Advertising,	$495 99		$5,861 39	
Labor,	21,853 17		118,751 49	
Professional services, medical services, analyses, etc.,	23 50		711 33	
Travelling,	4 20		1,648 98	
Rent,	-		37 00	
Water rates,	17 49		2,094 79	
Freight and express,	24 47		484 00	
Jobbing and repairing,	82 87		659 07	
Tools, machinery, appliances and hardware supplies,	283 56		15,880 30	
Castings, ironwork and metals,	32 28		207 85	
Iron pipe and valves,	156 28		3,386 31	
Blasting supplies,	-		41 29	
Paint and coating,	3 00		142 98	
Fuel, oil and waste,	994 06		1,977 86	
Lumber and field buildings,	191 28		6,670 02	
Drain pipe,	30		41 10	
Brick, cement and stone,	4 90		242 71	
Sand, gravel and filling,	-		269 45	
Municipal and corporation work,	176 22		220 29	
Unclassified supplies,	289 68		1,499 57	
Miscellaneous expenses,	333 75	24,967 00	583 44	161,311 22
Contracts, Wachusett Reservoir: —				
Contracts completed and final payments made prior to January 1, 1902,	-		$362,154 83	
Moulton & O'Mahoney, excavating soil and refilling at North Dike, Sect. 4,	$520 00		157,650 37	
Nawn & Brock, excavating soil, Sect. 6, and building easterly portion of North Dike,	291,562 26		969,416 62	
Busch Bros., excavating soil, Sect. 6, and building road, West Boylston and Boylston, — $600 due, deducted from estimate September 5, 1900,	-		34,560 63	
Long & Little, excavating soil, Sect. 7, and building part of North Dike,	68,960 79		220,003 15	
Newell & Snowling Construction Co., excavating soil from Sect. 8, and completing westerly portion of North Dike,	121,502 83		153,946 55	
Meskill Bros. & Leahy, excavating soil and building part of Worcester Street, West Boylston,	9,263 95		9,263 95	
Crary Construction Co., building Sect. 1 of the Relocation of Central Massachusetts Railroad,	24,412 37		24,412 37	
Amounts carried forward,	$516,222 20	$277,166 70	$1,931,408 47	$1,893,091 77

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1902.		From Beginning of Work, and ending December 31, 1902.	
Amounts brought forward, . . .	$516,222 20	$277,166 70	$1,931,408 47	$1,893,091 77
Construction — Con.				
Contracts, Wachusett Reservoir — *Con.*				
McArthur Bros. Co., building Sect. 2 of the Relocation of Central Massachusetts Railroad, ...	107,807 66		107,807 66	
Nawn & Brock, building Sect. 3 of the Relocation of Central Massachusetts Railroad,	24,300 86		24,300 86	
G. M. Atkins & Co., building Sect. 4 of the Relocation of Central Massachusetts Railroad, ...	31,080 20		31,080 20	
Wm. Cramp & Sons, bronze grooves for Wachusett Dam, ...	3,660 00		3,660 00	
McArthur Bros., Wachusett Dam, . .	356,483 48		516,405 12	
Camden Iron Works, special castings, . .	7,848 78		7,848 78	
Chapman Valve Manufacturing Co., valves, .	14,512 00		14,512 00	
*Coffin Valve Manufacturing Co., valves and iron work, ...	3,741 00		3,741 00	
*Davis & Farnum Manufacturing Co., special castings, ...	2,712 10		2,712 10	
*Davis & Farnum Manufacturing Co., special castings, ...	934 95		934 95	
*G. W. & F. Smith Iron Co., steel work for chambers, ...	3,000 00		3,000 00	
Taunton Locomotive Manufacturing Co., special castings, ...	1,203 37		1,203 37	
*United States Cast Iron Pipe and Foundry Co., cast iron pipe and special castings, .	1,514 80	1,075,021 40	1,514 80	2,650,129 31
Contracts, Wachusett Aqueduct: —				
Contracts completed and final payments made prior to January 1, 1902, . . .	-			1,447,208 55
Contracts, Sudbury Reservoir: —				
Contracts completed and final payments made prior to January 1, 1902, . . .	-			1,545,028 33
Contracts, improving Lake Cochituate: —				
Long & Little, excavation from Snake Brook Meadow, ...	$3,959 69		$14,196 49	
Auguste Saucier, Pegan Brook Meadow, .	39,553 89	43,513 58	39,553 89	53,750 38
Contracts, protection Cochituate Supply: —				
Town of Framingham, low-level sewer, .	-			9,000 00
Contracts, Rosemary siphon: —				
Contracts completed and final payments made prior to January 1, 1902, . . .	-			5,916 96
Contracts, pipe line, Dam No. 3 to Dam No. 1: —				
Contracts completed and final payments made prior to January 1, 1902, . . .	-			17,240 22
Contracts, Clinton sewerage system: —				
Contracts completed and final payments made prior to January 1, 1902, . . .	-			66,878 22
Amounts carried forward, . . .	. . .	$1,395,701 68		$7,688,243 74

* Including some iron work for Weston Aqueduct.

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1902.		From Beginning of Work, and ending December 31, 1902.	
Amounts brought forward,		$1,395,701 68		$7,683,243 74
Construction — Con.				
Contracts, Weston Aqueduct: —				
T. H. Gill, Sect. 1,	$18,398 80		$18,398 80	
Shanahan, Casparis & Co., Sect. 2,	93,265 47		132,828 69	
Shanahan, Casparis & Co., Sect. 3,	62,977 04		86,183 66	
Patrick McGovern, Sect. 4,	17,698 23		61,161 69	
Bruno, Salomone and Petitti, Sect. 5,	70,574 47		114,332 51	
Shanahan, Casparis & Co., Sect. 6,	56,409 72		76,899 56	
E. Kendall & Sons, steel pipe, Sects. 7 and 9,	102,589 54		102,589 54	
T. Bruno, blow-off, Sect. 9,	2,191 94		2,191 94	
Winston & Co., Sects. 8 and 10,	65,166 30		74,814 56	
Winston & Co., Sect. 11,	87,978 80		87,978 80	
Shanahan, Casparis & Co., Sect. 12,	66,813 44		94,198 15	
Michael H. Keefe, Sect. 13,	-		11,206 05	
Columbus Construction Co., Sect. 13,	192,757 74		217,569 34	
Nawn & Brock, Sect. 14,	26,841 68		26,841 68	
Winston & Co., Sect. 15,	85,394 84		88,721 42	
H. W. Worthington, castings for siphon chambers,	11,258 00		11,258 00	
Nawn & Brock, Weston Reservoir, Sect. 1,	8,453 25		8,453 25	
Nawn & Brock, Weston Reservoir, Sect. 2,	32,399 51		32,399 51	
Ward & Cummings, supply pipe lines, Sect. 1,	19,552 98		19,552 98	
Dennis F. O'Connell, supply pipe lines, Sect. 2,	59,301 11		59,301 11	
Thomas F. Moore, supply pipe lines, Sect. 4,	22,992 23		22,992 23	
Builders Iron Foundry, Venturi meters,	6,180 00		6,180 00	
Camden Iron Works, special castings,	2,284 84		2,284 84	
L. F. Childs, distributing pipe,	1,043 88		1,043 88	
Taunton Locomotive Mfg. Co., special castings and flanged pipe,	1,891 58	1,114,415 39	1,891 58	1,361,273 77
Contracts, Distribution System: —				
Contracts completed and final payments made prior to January 1, 1902,	-		$3,499,540 96	
Coleman Bros., pipe laying, Sect. 12,	$45,987 04		45,987 04	
C. E. Trumbull & Co., pipe laying, Sect. 12,	44,431 59		44,431 59	
T. Bruno, pipe laying, Sect. 30,	7,602 81		7,602 81	
Beckwith & Quackenbush, reservoir and foundation for standpipe, Forbes Hill,	5,832 44		37,253 61	
James E. McCoy, masonry tower, Forbes Hill,	14,193 90		25,967 95	
McNeil Bros., high-service pumping station, $1,500 due, deducted from final estimate May 22, 1901,	-		89,119 85	
C. H. Eglee, Bear Hill Reservoir,	8,332 29		24,894 47	
New England Structural Co., steel work for valve chambers,	1,056 00		1,056 00	
Daniel Russell Boiler Works Co., steel chambers for Venturi meters,	6,942 81		6,942 81	
Builders Iron Foundry, Venturi meters,	9,661 95		9,661 95	
Amounts carried forward,	$144,040 83	$2,510,117 07	$3,792,459 04	$9,049,517 51

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1902.		From Beginning of Work, and ending December 31, 1902.	
Amounts brought forward,	$144,040 83	$2,510,117 07	$3,792,459 04	$9,049,517 51
Construction — Con.				
Contracts, Distribution System — *Con.*				
Osgood & Witherly, frames and covers,	1,136 91		1,136 91	
*G. F. Blake Mfg. Co., special castings,	11,889 80		11,889 80	
Camden Iron Works, special castings,	11,172 40		11,172 40	
*United States Cast Iron Pipe and Foundry Co., special castings,	3,752 80		3,752 80	
United States Cast Iron Pipe and Foundry Co., cast-iron pipe and special castings,	175,495 00		175,495 00	
United States Cast Iron Pipe and Foundry Co., cast-iron pipe and special castings,	10,702 64		10,702 64	
*United States Cast Iron Pipe and Foundry Co., cast-iron pipe and special castings,	1,494 67		1,494 67	
*United States Cast Iron Pipe and Foundry Co., cast-iron pipe and special castings,	242,236 53		242,236 53	
*Warren Foundry and Machine Co., special castings,	2,901 30		2,901 30	
Coffin Valve Mfg. Co., valves,	2,763 00		2,763 00	
*Coffin Valve Mfg. Co., valves and sluice gates,	7,205 00		7,205 00	
*G. F. Blake Mfg. Co., valves,	11,940 00	626,730 88	11,940 00	
			$4,275,149 09	
Deduct value of pipes, valves, etc., included in above list, transferred to maintenance account December 31, 1900, and shown on page 47,	-		3,139 77	4,272,009 32
Additional work: —				
Labor,	$53,214 88		$506,416 87	
Professional services, medical services, analyses, etc.,	36 00		1,486 99	
Travelling,	161 57		1,088 22	
Rent,	430 00		3,387 37	
Water rates,	3 28		1,322 26	
Freight and express,	895 56		9,194 30	
Jobbing and repairing,	822 08		7,735 97	
Tools, machinery, appliances and hardware supplies,	2,329 21		64,881 65	
Electrical supplies,	4 50		4,776 00	
Castings, ironwork and metals,	6,852 67		49,757 38	
Iron pipe and valves,	7,175 03		49,981 51	
Blasting supplies,	279 07		1,138 48	
Paint and coating,	108 78		3,709 96	
Fuel, oil and waste,	3,778 47		9,448 81	
Lumber and field buildings,	1,842 62		72,669 72	
Drain pipe,	2,289 12		6,777 29	
Brick, cement and stone,	1,778 43		14,563 55	
Sand, gravel and filling,	131 00		4,814 37	
Municipal and corporation work,	19,277 30		84,031 17	
Police service,	32,483 60		155,942 22	
Amounts carried forward,	$133,893 17	$3,136,847 95	$1,053,124 09	$13,321,526 83

* Including some iron work for other departments.

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1902.		From Beginning of Work, and ending December 31, 1902.	
Amounts brought forward,	$133,893 17	$3,136,847 95	$1,053,124 09	$13,321,526 83
Construction — Con.				
Additional work — *Con.*				
Sanitary inspection,	1,728 26		7,869 87	
Judgments,	12,047 05		32,028 94	
Unclassified supplies,	1,041 40		9,018 14	
Miscellaneous expenses,	371 51		2,691 53	
		149,081 39		1,104,732 57
Legal and expert: —				
Legal services,	$50 00		$4,668 82	
Expert services,	-		475 87	
Court expenses,	414 20		774 51	
Miscellaneous expenses,	15 70		49 05	
		479 90		5,968 25
Real Estate.				
Legal and expert: —				
Legal services,	-		$4,736 31	
Conveyancer and assistants,	$8,513 50		85,487 16	
Experts,	278 00		17,173 58	
Appraisers,	2,328 00		17,459 34	
Court expenses,	1,635 68		3,930 20	
Counsel expenses,	-		43 25	
Conveyancing supplies,	98 22		2,989 22	
Conveyancing expenses,	504 23		5,036 19	
Miscellaneous expenses,	2,673 87		3,591 32	
Settlements made by Board,	158,010 66		3,049,767 67	
Judgments,	23,575 58		56,328 62	
Taxes and tax equivalents,	480 24		67,493 15	
Care and disposal,	13,512 40		51,569 15	
		211,610 38		3,365,605 16
Damages to Real Estate not taken, to Business, and on Account of Loss of Wages.				
Legal and expert: —				
Legal services,	-		$1,130 67	
Expert services,	$85 00		85 00	
Court expenses,	3,386 69		4,840 55	
Settlements,	93,343 75		267,302 16	
Judgments,	50,553 40		50,553 40	
		147,368 84		323,911 78
Claims on Account of Diversion of Water.				
Legal and expert: —				
Legal services,	-		$3,774 98	
Expert services,	$4,706 58		17,937 22	
Court expenses,	7,245 54		9,589 33	
Miscellaneous expenses,	48 72		1,222 63	
Settlements,	-		917,350 00	
		12,000 84		949,874 16
Purchase of Existing Water Works.				
Legal and expert: —				
Legal services,	-		$1,878 89	
Expert services,	-		2,650 65	
Miscellaneous expenses,	-		952 94	
*Settlements and judgments,	-		14,012,620 10	
				14,018,102 58
Total amount of construction expenditures,		$3,657,389 30		$33,089,721 38

* Including transfers from Sudbury Works.

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1902.	From Beginning of Work, and ending December 31, 1902.
II. MAINTENANCE AND OPERATION OF WORKS.		
Administration: —		
Commissioners,	$2,333 33	$10,733 33
Secretary, auditor and assistants,	2,091 81	19,085 87
Postage, printing, stationery and other supplies,	650 70	2,462 18
Travelling,	394 96	1,001 88
Telephone, heating, lighting and care of building,	478 42	2,379 91
Alterations and repairs of building,	104 06	1,554 68
Rent and taxes, office building,	160 00	455 60
Miscellaneous expenses,	58 75	409 39
Supervision and general superintendence: —		
Chief engineer and department engineers,	7,399 66	34,587 98
Engineering and clerical assistants,	7,129 92	33,661 02
Postage, printing, stationery and office supplies,	599 41	3,688 90
Telephone, heating, lighting and care of offices,	1,285 48	5,354 53
Travelling and incidental expenses,	343 74	2,339 86
Alterations and repairs of buildings,	217 19	5,477 04
Rent and taxes, main office,	450 00	1,169 59
Miscellaneous expenses,	226 29	1,288 41
Pumping service: —		
Labor,	45,737 91	184,409 46
Fuel,	40,473 64	163,968 14
Oil, waste and packing,	1,618 22	6,920 54
Repairs and renewals,	8,386 53	25,176 59
Small supplies and expenses,	3,198 04	12,187 35
Pumping by municipalities,	-	45,273 80
Rent, West Roxbury pumping station,	820 00	2,660 00
Superintendents and assistant superintendents,	3,387 90	15,344 66
Engineering assistants,	9,567 75	37,510 33
Laboratory force,	2,123 62	12,439 60
Sanitary inspectors,	3,056 04	12,697 16
Recording and scientific instruments and supplies,	258 84	2,417 84
Labor and teaming,	85,728 73	364,431 92
Tools, machinery and appliances,	1,724 68	8,892 25
Lumber and hardware supplies,	4,231 40	12,397 07
Jobbing and repairing,	1,719 85	9,389 02
Travelling,	3,815 84	13,584 14
Horses, vehicles and stable expenses,	3,889 37	17,215 39
Fuel, lighting and telephone,	4,010 14	14,086 73
Municipal and corporation work,	255 80	4,094 59
Alterations and repairs of buildings,	26 48	429 45
Settlements of claims,	-	1,000 00
Unclassified supplies,	5,907 42	21,507 88
Amounts carried forward,	$253,861 92	$1,113,684 08

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1902.		From Beginning of Work, and ending December 31, 1902.	
Amounts brought forward,	$253,861 92		$1,113,684 08	
MAINTENANCE, ETC. — *Con.*				
Miscellaneous expenses,	1,078 14		5,405 10	
Conveyancer and assistants,	10 99		363 84	
Taxes and tax equivalents,	31,468 39		78,592 56	
Contracts and agreements,	4,970 98		58,755 92	
Contracts for pipes, valves, etc., bought from construction work since January 1, 1901,	2,654 72		5,392 74	
Contracts for pipes, valves, etc., originally charged to construction, transferred to maintenance previous to January 1, 1901 (included in list, pages 43, 44),	-		3,139 77	
Total expenditures for maintenance and operation,		$294,045 14		$1,265,334 01

(*b*) *Receipts.*

The total amount of receipts from rents, sales of property, etc., for the year beginning January 1, 1902, and ending December 31, 1902, is $65,054.06; and the total amount from the time of the organization of the Board, July 19, 1895, to December 31, 1902, is $279,770.62. The general character of these receipts is as follows: —

GENERAL CHARACTER OF RECEIPTS.	For the Year ending December 31, 1902.		From Beginning of Work, and ending December 31, 1902.	
For distribution back to District: —				
District entrance fees,	-		$65,005 00	
Supplying water outside of District,	$3,000 00		28,405 64	
Water furnished to water companies,	17,774 17	$20,774 17	35,652 44	$129,063 08
To the credit of the loan fund: —				
Real estate and buildings,	$1,963 83		$11,833 83	
Labor, tools and supplies,	25,120 35	27,084 18	46,363 93	58,197 76
To the credit of the sinking fund: —				
Forfeiture for contracts awarded but not executed,	-		$500 00	
Rents,	$10,311 03		70,124 07	
Land products,	6,812 62		21,494 66	
Unclassified receipts,	72 06	17,195 71	391 05	92,509 78
Total receipts,		$65,054 06		$279,770 62

The foregoing receipts have been credited to the various objects or works, as follows: —

RECEIPTS FROM DIFFERENT WORKS.	For the Year ending December 31, 1902.		From Beginning of Work, and ending December 31, 1902.	
Distribution back to District: —				
Admission into Metropolitan Water District (Nahant, Quincy, Stoneham and Arlington),	-		$65,005 00	
Supplying water to towns outside of Water District (Swampscott and Lexington),	$3,000 00		28,405 64	
Water furnished to water companies,	17,774 17	$20,774 17	35,652 44	$129,063 08
Construction and acquisition of works: —				
Administration,	-		$0 75	
Wachusett Dam,	$4,445 00		4,897 09	
Wachusett Reservoir,	16,763 19		83,931 55	
Wachusett Aqueduct,	4,699 75		5,204 70	
Weston Aqueduct,	97 77		1,218 28	
Sudbury Reservoir and watershed,	5 96		7,255 16	
Distribution system,	14,834 78		31,310 83	
Diversion of water, Clinton sewerage system,	-		656 91	
Purchase of existing water works,	1,085 00	41,931 45	6,373 12	140,848 39
Maintenance and operation of works: —				
Wachusett Aqueduct,	$516 08		$2,098 19	
Sudbury system,	998 36		5,021 64	
Distribution system,	303 82		1,520 70	
Clinton sewerage system,	530 18	2,348 44	1,218 62	9,859 15
Total receipts,	. . .	$65,054 06		$279,770 62

(c) *Assets.*

The following is an abstract of the assets of the Water Works, a complete schedule of which is kept on file in the office of the Board: —

Office furniture, fixtures and supplies; engineering and scientific instruments and supplies; police supplies; horses, vehicles, field machinery, etc.; machinery, tools and other appliances and supplies; real estate connected with works not completed; completed works, including real estate and buildings connected therewith.

(d) *Liabilities.*

There are liabilities as follows: —

Current bills unpaid,	$42,400 00*
Due on monthly pay rolls,	4,220 00
	$46,620 00

* Miscellaneous current bills of 1902, including those coming in from time to time after January 1, 1903, have since been paid.

Amounts reserved on Monthly Estimates, not due until Completion of Contracts or until Claims are settled.

NAME.	Work.	Amount.
McArthur Bros. Co., . . .	Wachusett Dam, . . .	$36,836 20
Busch Bros., ...	Building road, Wachusett Reservoir, ...	600 00
Nawn & Brock, ...	Wachusett Reservoir, Sect. 6,	10,000 00
Newell & Snowling Construction Co.,	Wachusett Reservoir, Sect. 8,	27,167 04
McNeil Bros., ...	High-service pumping station, Items 8 and 9, . .	1,500 00
Auguste Saucier, ...	Improving Lake Cochituate, Pegan Meadow, . . .	6,662 45
T. H. Gill & Co., ...	Weston Aqueduct, Sect. 1, .	2,052 73
Shanahan, Casparis & Co., . .	Weston Aqueduct, Sect. 2, .	2,631 53
Shanahan, Casparis & Co., . .	Weston Aqueduct, Sect. 3, .	2,108 88
Bruno, Salomone & Petitti, . .	Weston Aqueduct, Sect. 5, .	5,000 00
Shanahan, Casparis & Co., . .	Weston Aqueduct, Sect. 6, .	1,805 81
E. Kendall & Sons, ...	Weston Aqueduct, Sects. 7 and 9, ...	8,104 04
Winston & Co., ...	Weston Aqueduct, Sects. 8 and 10, ...	4,884 92
Winston & Co., ...	Weston Aqueduct, Sect. 11, .	6,949 20
Shanahan, Casparis & Co., . .	Weston Aqueduct, Sect. 12, .	1,432 03
Columbus Construction Co., . .	Weston Aqueduct, Sect. 13, .	20,000 00
Nawn & Brock, ...	Weston Aqueduct, Sect. 14, .	4,736 77
Winston & Co., ...	Weston Aqueduct, Sect. 15, .	8,509 66
Nawn & Brock, ...	Weston Reservoir, Sect. 1, .	1,491 75
Nawn & Brock, ...	Weston Reservoir, Sect. 2, .	4,094 03
Crary Construction Co., . . .	Relocation Central Massachusetts Railroad, Sect. 1, .	4,308 06
McArthur Bros. Co., . . .	Relocation Central Massachusetts Railroad, Sect. 2, .	8,330 76
G. M. Atkins & Co., ...	Relocation Central Massachusetts Railroad, Sect. 4, .	5,484 74
Ward & Cummings, ...	Supply pipe lines, Sect. 1, .	3,450 53
Dennis F. O'Connell, . . .	Supply pipe lines, Sect. 2, .	9,723 73
Thomas F. Moore, ...	Supply pipe lines, Sect. 4, .	1,998 63
G. F. Blake Mfg. Co., . . .	Special castings, . . .	2,098 20
Camden Iron Works, . . .	Special castings, . . .	1,971 60
United States Cast Iron Pipe and Foundry Co., ...	Cast iron pipe and special castings, ...	30,969 71
Coleman Bros., ...	Pipe laying, Medford, Sect. 12,	7,762 42
		$232,665 42

Amounts have been agreed upon in the following cases, but the deeds have not passed: —

Godfrey Fuller, $20; Mary E. Dolan *et al.*, $610; Nathan Eugene Upham, $3,680.25; George A. Bacon, $75; George L. Butler *et*

als., $647 ; Sarah E. Kirby, $1,950 ; William O. Johnson, $7,250 ; James M. Wilson, $2,250.

On the claims of the following it is impossible to state the amounts due for land damages and water rights, as suits are now pending in the courts for the determination of the same : —

Patrick T. Moran, estate of William H. Buck, estate of Henrietta M. Johnson, Charles L. Johnson, Charles B. Sawin, Bigelow Carpet Company, Charles E. Nichols, J. M. Sears, city of Malden balance, city of Medford, city of Melrose, Edward A. Cowee, heirs of Hanson Chase, Boston & Maine Railroad, American Telephone and Telegraph Company, Delina Mallett, John F. O'Brien, Boston & Albany Railroad Company, Emory A. Bacon, Frances A. Wilder *et al.*, Frances H. Chase, administratrix, Nashua River Paper Company, George L. Redding, James Dorr, Charles U. Cotting *et als.*, Framingham Water Company, Charles W. Felt, Johanna T. Dunn, Katherine Cameron, Robert F. Perkins, Francis Shaw, Abner S. Vose, Elizabeth F. Bowditch *et als.*, Julius Heinig, Theresa Graichen, Andrew Leinhardt, James B. Marsh, Catherine McGuinness, town of West Boylston.

V. SEWERAGE WORKS — CONSTRUCTION.

The Metropolitan Sewerage Works embrace the North Metropolitan System and the South Metropolitan System.

(1) North Metropolitan System.

The North Metropolitan System provides for the cities and towns of Arlington, Belmont, Cambridge, Chelsea, Everett, Malden, Medford, Melrose, Somerville, Stoneham, Wakefield, Winchester, Winthrop, Woburn, a part of the town of Lexington, and the parts of the city of Boston known as East Boston and Charlestown, all situated in the Charles River and Mystic River valleys, but wholly north of the Charles River.

The North Metropolitan District has an area of 84.64 square miles, and an estimated population of 452,100, of which 342,321 contribute sewage to the system. The length of the Metropolitan sewers in this system is 55.391 miles.

No additional Metropolitan sewers have been constructed during the year, the system, so far as at present authorized, having been substantially completed during the preceding year.

The sum of $56,161.71 was expended during the year 1902.

The amount of appropriations under the various acts was $5,605,-865.73, and the receipts from sales of real estate and from miscellaneous sources amounted to $16,526.73, — a total of $5,622,392.46. There had been expended up to the year ending December 31, 1902, $5,621,869.52.

The attention of the Legislature has been called by a special report to the necessity for an additional appropriation on account of this system.

(2) South Metropolitan System.

The South Metropolitan System provides for the cities and towns of Brookline, Hyde Park, Milton, Newton and Quincy, a part of the town of Dedham, and the Brighton district and portions of the Back Bay, Dorchester, Roxbury and West Roxbury districts in the city of Boston, all situated on the south side of the Charles River, and the city of Waltham and the town of Watertown, situated on the north side of that river. This system provides for the sewage of a portion of the Charles River valley and of a portion of the Neponset River valley.

The South Metropolitan District embraces an area of 102.55 square miles, having an estimated population of 291,700, of which contribution is made to the sewage by 130,895.

The system includes the Charles River valley sewer, which has been entirely completed; the Neponset River valley sewer, which has been substantially completed during the year 1902; and the High-level sewer, of which the construction is in active progress. The length of the Charles River sewer is 8.15 miles; of the Neponset River sewer, 12.57 miles; and of the High-level sewer, as projected, 16.83 miles.

The portion of the Neponset River valley sewer which was completed during the year 1902 is situated in West Roxbury and Newton, and about 4,915 feet were constructed.

The chief work of construction on account of the Metropolitan Sewerage Works has been carried on upon the High-level sewer, which is to extend from the foot of the northerly side of Parker Hill in Roxbury, through portions of Jamaica Plain, Hyde Park, Milton and Quincy to Nut Island, whence outfall pipes are to be laid about a mile in length in the bed of the harbor. Of the entire length of 16.83 miles, about 13.21 miles have been completed, or carried to an

advanced stage of construction. On 2.83 miles but little work has been accomplished, or the work is still to be begun; only 0.79 of a mile yet remains to be contracted for. Of the entire length of the sewer, 4.08 miles will be in tunnel.

The work in general has been carried on satisfactorily during the year, and it is expected that the sewer will be substantially completed as far as Nut Island in the coming season. Considerable difficulty was experienced by the contractors in the construction of a portion of the tunnel located in South and Centre streets, West Roxbury. This section has a total length of 4,775 feet, and is in tunnel at a depth of about 50 feet below the surface of the ground. As the progress made had not been sufficient to insure the completion of the section in time for use in connection with the other portions of the sewer, the Board terminated the contract early in the year, and has since carried on the work by day labor. The tunnel is built largely in sand, which in some places is very fine, and the construction has been carried on with the use of pneumatic pressure and metallic roof-plates. The rate attained will insure the satisfactory completion of the section.

During the past year Nut Island has been levelled by removing the upper portion of the island, and, with the material acquired, an embankment has been built from the island to the main shore at Hough's Neck. This embankment when finished will have a top elevation of about 27 feet above low water, and a top width of 25 feet.

On Nut Island a screen house will be erected, from which outfall pipes about a mile each in length will lead out into the harbor, having outlets about 1,500 feet apart. Work has been carried on upon one of the lines during the past season. Sixty-inch cast-iron spigot and socket pipes are laid in trenches dredged in the bottom of the harbor. The bottom of the pipes will have an average depth of about 9 feet below the bottom of the harbor, a maximum of 51 feet below mean high water. The trench is dug 2 feet deeper, and piles for supporting the pipes are driven in pairs at intervals of 6 feet. Satisfactory progress has been made in the laying of the pipes. A contract for laying the second line of pipes will be made early in the present year.

A contract was executed in October of last year for the erection of the large pumping station required for the High-level sewer at the

HIGH-LEVEL SEWER—NUT ISLAND AND BAR, BEFORE BEGINNING OF WORK AND AFTER CONSTRUCTION OF EMBANKMENT AND GRADING OF ISLAND.

corner of Ward and Vancouver streets in Roxbury. The entire structure, comprising the engine room, boiler room, coal house and screening chamber, will have an area of 15,000 square feet. The building will be of hard brick with granite trimmings, while the foundations will be made of Portland concrete. A contract has also been made for furnishing and erecting two vertical triple-expansion pumping engines, having each a daily capacity of 50,000,000 gallons, together with the boilers and other appurtenances. It is expected that the pumping station and its equipment will be finished by January in the year 1904.

An additional contribution will be needed for the completion of the High-level sewer, as appears in the special report of the Board to the Legislature, and also a small amount for the settlement of land damages on account of the Neponset River valley system.

(3) Purchases and Takings of Land.

Only two takings of real estate, covering an area of 6.96 acres, have been made for the Metropolitan Sewerage Works, both for the purposes of the High-level sewer in the South Metropolitan System, one being of easements in public ways in Milton, and the other of easements in parts of three public ways and in land of one private owner in Roxbury.

List of Takings for Metropolitan Sewerage Works for the Year 1902.

No.	LOCATION AND DESCRIPTION.	Former Owners.	Recorded.	Sections and Purpose of Taking.
			1902.	
6	Milton (in and from Canton Avenue, near Brook Road to Pine Tree Brook). Area, easements in 5.48 acres.	Town of Milton, .	May 9,	Section 61, High-level sewer.
7	Roxbury (in and near Vancouver Street). Area, easements in 1.48 acres.	City of Boston *et al.*,	Oct. 3,	Section 78, High-level sewer.

The above acreage in which easements were taken includes 6.91 acres in public streets.

Since January 1, 1902, settlements have been effected on account of the takings made in the North Metropolitan District in 4 cases, involving a payment of $34,719.92; and in cases in the South Metropolitan District 20 settlements have been effected, under which payments have been made amounting to $29,289.70.

Summary of Land Settlements for the Year 1902.

LOCATION.	Area in Acres.	Number of Settlements.	Payments.
North Metropolitan District.			
Chelsea,	1.075	1	$500 00
Melrose,	.260	1	1.250 00
Boston (Charlestown),	1.171	2	32,969 92
Total,	2.506	4	$34,719 92
South Metropolitan District.			
West Roxbury,	2.450	5	$16,800 83
Roxbury,	.099	3	850 00
Boston,	.224	2	1,800 00
Quincy,	1.767	4	5,873 75
Milton,	.249	5	3,934 32
Dedham,	.035	1	30 80
Total,	4.824	20	$29,289 70
Aggregates,	7.330	24	$64,009 62

VI. SEWERAGE WORKS — MAINTENANCE.

The sewerage department has in charge the care of the completed sewers and outlets, and the maintenance of the various pumping stations.

The maintenance force consists of 47 engineers and other employés in charge of the pumping stations, and 33 men employed in connection with the care of the sewers and of grounds about the stations.

Prior to the present year, the teams necessary for the repair and care of the sewers and grounds were hired; but this practice has been discontinued, and during the past year four teams and their equipments have been purchased for the works.

(1) North Metropolitan System.

Sewage is received into the Metropolitan sewers belonging to this District from local sewers having a total length of 503.46 miles, and having 53,854 connections.

The total number of gallons of sewage pumped has been 50,116,-025,000. Of this total, 18,814,800,000 gallons have been pumped at the Deer Island station, 18,067,200,000 gallons at the East Boston station, 11,868,900,000 gallons at the Charlestown station, and 1,365,125,000 gallons at the Alewife Brook station.

The average cost of pumping per million gallons raised one foot, including labor at the screens, was, at the Deer Island station, \$0.096; at the East Boston station, \$0.076; at the Charlestown station, \$0.179; and at the Alewife Brook station, \$0.290.

During the year an additional salt-water suction pipe, 12 inches in diameter, has been laid from the Deer Island pumping station to a point nearly 400 feet beyond high water, the outlet being at a depth of about 6 feet of water at low tide.

The Shirley Gut siphon, which had been partly denuded by the changes in the bed of the channel, has been protected by the laying of a large quantity of additional riprap.

A brick chamber, 14 feet square and 9 feet high, with granite trimmings, has been erected at Charlestown over the siphon shaft of the sewer which crosses the Mystic River, including arrangements for extracting the gases which tend to accumulate in the shaft.

(2) South Metropolitan System.

Sewage is received in this system from local sewers having a length of 366.42 miles, and 17,978 connections.

The Quincy pumping station is the only one as yet operated in the South Metropolitan System. The total number of gallons of sewage pumped here has been 814,007,000, at an average cost of \$0.196 per million gallons raised one foot.

VII. SEWERAGE WORKS — FINANCIAL STATEMENT.

(1) Construction Loans and Receipts.

The appropriations for the construction of the Metropolitan Sewerage Works, the receipts which are added to the appropriations, and the expenditures for construction, have been as follows: —

(a) *North Metropolitan System.*

Appropriations under various acts of the Legislature (given in detail in preceding report),	\$5,605,865 73
Proceeds from sales of property and from other sources to December 31, 1902 (of which \$469.20 is for the year 1902),	16,526 73
	\$5,622,392 46
Amount approved by the Metropolitan Sewerage Commission and the Metropolitan Water and Sewerage Board for payment to December 31, 1902 (of which \$56,161.71 is for the year 1902),	5,621,869 52
Balance January 1, 1903,	\$522 94

(b) *South Metropolitan System.*

Charles River Valley Sewer.

Appropriations under the Acts of the years 1899 and 1900,	$800,046 27
Amount approved by the Metropolitan Sewerage Commission for payment to December 31, 1902,	800,046 27
No balance January 1, 1903,	–

Neponset River Valley Sewer.

Appropriations under various acts of the Legislature (given in detail in preceding report),	$900,000 00
Proceeds from pumping ground water,	109 50
	$900,109 50
Amount approved by the Metropolitan Sewerage Commission and the Metropolitan Water and Sewerage Board for payment to December 31, 1902 (of which $33,707.66 is for the year 1902),	899,997 82
Balance January 1, 1903,	$111 68

High-level Sewer.

Appropriation under chapter 424 of the Acts of 1899, original loan,	$4,600,000 00
Proceeds from sales of property to December 31, 1902 (of which $1,020.71 is for the year 1902),	1,595 71
	$4,601,595 71
Amount approved by the Metropolitan Sewerage Commission and the Metropolitan Water and Sewerage Board for payment to December 31, 1902 (of which $2,078,095.43 is for the year 1902),	3,841,988 01
Balance January 1, 1903,	$759,607 70

(c) *Metropolitan Sewerage Loans Sinking Fund.*

Under authority of chapter 122 of the Acts of 1899, and section 14 of chapter 424 of the Acts of 1899, the Treasurer of the Commonwealth was required to consolidate the sinking funds of all the Metropolitan sewerage loans into one fund, to be known as the Metropolitan Sewerage Loans Sinking Fund.

The sinking fund as thus established has amounted at the end of each year to sums as follows: —

December 31, 1899,	$361,416 59
December 31, 1900,	454,520 57
December 31, 1901,	545,668 26
December 31, 1902,	636,084 04

(2) Annual Appropriations and Receipts.

The annual appropriations for the maintenance of the Metropolitan Sewerage Works, the receipts of the Board which are added to the appropriations for maintenance, and the expenditures for maintenance for the year ending December 31, 1902, have been as follows: —

North Metropolitan System.

Balance January 1, 1902,	$12,952 67
Appropriation under chapter 51 of the Acts of 1902,	103,400 00
Receipts from pumping and from other sources,	971 08
	$117,323 75
Amount approved by the Boards for payment,	108,994 99
Balance January 1, 1903,	$8,328 76

South Metropolitan System.

Balance January 1, 1902,	$11,519 28
Appropriation under chapter 13 of the Acts of 1902,	93,666 00
Receipts from sales of property and from pumping,	22 60
	$105,207 88
Amount approved by the Boards for payment,	99,668 11
Balance January 1, 1903,	$5,539 77

The Board has also received, from rentals and from other sources, to be applied by the Treasurer of the Commonwealth to the Metropolitan Sewerage Loans Sinking Fund requirements, $161.67.

(3) Annual Assessments.

The commissioners appointed under chapter 439 of the Acts of the year 1889, to determine the proportion in which each of the cities and towns forming the North Metropolitan System should annually pay money to meet the interest and sinking fund requirements, and to defray the cost of maintenance and operation of that system, determined the proportions in percentages payable by the several cities and towns for the period beginning with the year 1901 and ending with the year 1905, as follows: —

CITY OR TOWN.	Proportions in Percentages for Interest and Sinking Fund, based on Valuation.	Proportions in Percentages for Maintenance and Operation, based on Population.
Arlington,	2.39	2.06
Belmont,	1.50	.94
Boston: —		
East Boston, Charlestown,	16.89	20.66
Cambridge,	25.75	21.96
Chelsea,	6.20	8.14
Everett,	4.81	5.82
Lexington: —		
Centre Lexington, East Lexington,	.90	.32
Malden,	8.16	8.05
Medford,	5.40	4.36
Melrose,	3.41	3.10
Somerville,	13.87	14.74
Stoneham,	1.35	1.48
Wakefield,	2.35	1.78
Winchester,	2.41	1.73
Winthrop,	1.81	1.45
Woburn,	2.80	3.41
Totals,	100.00	100.00

The commissioners appointed under chapter 424 of the Acts of the year 1899, to determine the proportion in which each of the cities and towns of the South Metropolitan System should annually make payment to meet the interest and sinking fund requirements, and to defray the cost of maintenance and operation of that system, determined the proportions in percentages payable by the several cities and towns for the period beginning with the year 1900 and ending with the year 1904, to be as follows: —

CITY OR TOWN.	Proportions in Percentages for Interest and Sinking Fund, based on Valuation.	Proportions in Percentages for Maintenance and Operation, based on Population.
Waltham,	5.08	10.14
Watertown,	2.66	3.78
Newton,	15.30	13.41
Boston: —		
Brighton district, Back Bay district, Roxbury district, West Roxbury district, Dorchester district,	42.42	43.30
Brookline,	19.23	7.86
Dedham,	2.13	3.02
Hyde Park,	2.52	5.75
Milton,	5.75	2.68
Quincy,	4.91	10.06
Totals,	100.00	100.00

(4) Expenditures for the Different Works.

The following is a summary of the expenditures made in the various operations for the different works: —

CONSTRUCTION.	For Year ending December 31, 1902.		From Beginning of Work to December 31, 1902.	
North Metropolitan System.				
Original system, main line and branches,	$39,592 15		$5,190,374 68	
Lexington branch,	-		68,585 15	
Everett branch,	-		54,877 12	
Wakefield branch,	-		35,698 29	
Stoneham branch,	-		11,574 10	
Chelsea and Everett outlets,	3,195 70		71,001 41	
Wakefield branch extension,	13,373 86		189,758 77	
Total, North Metropolitan System,		$56,161 71		$5,621,869 52
South Metropolitan System.				
Charles River valley sewer,	-			$800,046 27
Neponset River valley sewer, main line,	$8,001 48		$864,804 16	
Brookline branch,	25,706 18		35,193 66	
Total,		$33,707 66		899,997 82
High-level sewer: —				
Section 43, Quincy,	$123,092 58		$131,664 45	
Section 44, Quincy,	88,575 18		94,774 61	
Section 45, Quincy,	8,732 16		12,357 78	
Section 46, Quincy,	23,800 91		27,598 52	
Section 47, Quincy,	96,080 92		104,524 20	
Section 48, Quincy,	6,249 21		11,213 76	
Sections 48 and 49, Quincy,	53,358 74		77,811 74	
Section 49, Quincy,	48,603 95		106,093 13	
Section 50, Quincy,	93,385 88		104,268 86	
Section 51, Quincy,	25,739 07		86,976 85	
Section 52, Quincy,	120,962 90		183,842 22	
Section 53, Quincy,	76,061 79		84,509 94	
Section 54, Quincy,	89,595 86		97,110 65	
Section 55, Quincy and Milton,	189,630 28		296,291 39	
Section 56, Milton,	21,722 67		104,834 22	
Section 57, Milton,	56,794 40		65,138 33	
Section 58, Milton,	85,235 05		91,408 33	
Section 59, Milton,	89,903 88		100,068 28	
Section 60, Milton,	52,723 64		57,105 74	
Section 61, Milton,	89,924 56		93,501 21	
Section 62, Milton,	19,155 24		129,258 27	
Section 63, Milton,	42,179 31		126,597 68	
Section 64, Neponset River crossing,	40,138 37		43,995 65	
Section 65, Hyde Park,	108 75		40,611 88	
Section 66, Hyde Park,	102,675 36		217,533 49	
Section 67, Hyde Park, Stony Brook crossing,	23,837 05		31,139 46	
Section 68, Hyde Park and Roxbury,	218 16		78,431 82	
Section 69, West Roxbury,	101 50		101,963 14	
Section 70, West Roxbury,	25,100 73		111,608 17	
Section 71, West Roxbury,	4,240 25		91,828 92	
Section 72, West Roxbury,	10,976 90		122,228 88	
Section 73, West Roxbury,	190,751 38		230,429 66	
Section 74, West Roxbury and Roxbury,	24,552 13		146,880 41	
Section 75, Roxbury,	82,237 04		118,439 82	
Section 76, Roxbury, cast-iron force main,	3,890 39		7,472 51	
Section 77, Roxbury, Ward Street pumping station,	15,552 07		26,525 86	
Section 78, Roxbury, connecting sewer,	6,751 70		7,992 60	
Real estate,	36,602 66		291,381 11*	
Apportionment Commission,	-		2,000 00	
Administration,	8,858 81		34,574 47	
Total,		2,078,095 43		3,841,988 01
Total, South Metropolitan System,		$2,111,803 09		$5,542,032 10
Total for construction, both systems,		$2,167,964 80		$11,163,901 62

* Including $61,300.20 paid for Ward Street pumping station lot, and estimated amount of $14,000 for part of Adams estate purchase on account of sand for use in connection with construction of Section 48.

MAINTENANCE.	For Year ending December 31, 1902.	From Beginning of Work to December 31, 1902.
North Metropolitan System,	$108,994 99	$661,940 38
South Metropolitan System,	99,668 11	548,549 90
Total for maintenance, both systems,	$208,663 10	$1,210,490 28

(5) Detailed Financial Statement.

The Board herewith presents, in accordance with the Metropolitan Sewerage Acts, an abstract of the expenditures and disbursements, receipts, assets and liabilities for the year ending December 31, 1902: —

(*a*) *Expenditures and Disbursements.*

GENERAL CHARACTER OF EXPENDITURES.	For Year ending December 31, 1902.
North Metropolitan System — Construction.	
Engineers, inspectors, rodmen, laborers and others,	$43 21
Advertising,	5 43
Postage, telephone and telegrams,	31 99
Books, maps, plans, blue prints and photography,	38
Carriage hire and travelling expenses,	9 75
Teaming and express,	21 50
Tools and repairs of same,	4 05
Brick, cement, lumber and other field supplies,	757 18
Contracts: —	
Chelsea and Everett outlets: —	
H. A. Hanscom & Co., Sect. 56,	1,470 93
H. A. Hanscom & Co., Sect. 57,	1,148 83
Wakefield branch extension: —	
Bruno, Salomone & Petitti, Sect. 58,	2,584 77
Chas. G. Belden & Co., Sect. 59,	2,511 57
Metropolitan Contracting Co., Sect. 60 (part),	6,277 33
Land takings, purchase and recording,	34,773 72
Experts and appraisers,	3,581 07
Legal services,	65 00
Claims and allowances on contracts,	1,000 00
Pumps and alterations, pumping plants,	1,875 00
Total,	$56,161 71
Neponset River Valley Sewer — Construction.	
Engineers, inspectors, rodmen, laborers and others,	$1,365 00
Postage, telephone and telegrams,	68 65
Books, maps, plans, blue prints and photography,	1 90
Engineering supplies,	38 63
Carriage hire and travelling expenses,	68 30
Brick, cement, lumber and other field supplies,	1,014 76
Amount carried forward,	$2,557 24

GENERAL CHARACTER OF EXPENDITURES.	For Year ending December 31, 1902.
Amount brought forward,	$2,557 24
Neponset River Valley Sewer — Construction — Con.	
Contracts: —	
Brookline branch: —	
Thos. J. Kelley, Sect. 30,	22,544 44
Land takings, purchase and recording,	6,681 63
Experts and appraisers,	1,924 35
Total,	$33,707 66
High-level Sewer — Construction.	
Commissioners,	$2,333 34
Secretary, engineer and auditor,	4,525 00
Clerical services,	3,715 83
Engineers, inspectors, rodmen, laborers and others,	193,600 96
Advertising,	240 66
Office supplies,	2,315 61
Postage, telephone and telegrams,	1,619 60
Books, maps, plans, blue prints and photography,	677 13
Printing maps and reports,	126 67
Engineering instruments and repairs of same,	567 85
Engineering supplies,	2,405 91
Carriage hire and travelling expenses,	5,380 15
Repairs, fittings and supplies, main office,	219 55
Rent of office, Pemberton Building,	3,127 00
Rent of sub-offices,	653 13
Water rates and connections,	7,137 51
Rent of office, Ashburton Place,	600 00
Rent of Farrington lot,	300 00
Rent of wharf, Quincy,	900 00
Teaming and express,	3,569 33
Tools and repairs of same,	12,660 98
Brick, cement, lumber and other field supplies,	97,187 28
Contracts: —	
United States Cast Iron Pipe and Foundry Co., Sect. 43,	76,610 28
Hiram W. Phillips, Sect 43,	17,236 51
Wm. H. Ellis, Nut Island Wharf,	10,245 04
Wm. H. Ellis, Riprap at Nut Island,	20,554 24
Wm. H. Ellis, Nut Island Embankment,	73,759 37
Latta & Terry Co., Sect. 45,	7,854 59
John Cashman, Sect. 46,	20,885 34
Chas. G. Belden & Co., Sect. 47,	89,568 36
Chas. G. Belden & Co., Sects. 48, 49, embankments,	48,791 33
Chas. G. Belden & Co., Sect. 49,	44,581 63
Chas. G. Belden & Co., Sect 50,	86,231 99
Thomas F. Moore, Sect. 51,	24,016 76
National Contracting Co., Sect. 52,	115,045 25
National Contracting Co., Sect. 53,	71,845 13
National Contracting Co., Sect. 54,	85,638 20
H. P. Nawn, Sect. 55,	166,533 50
National Contracting Co., Sect. 56,	20,799 86
Amount carried forward,	$1,324,060 87

GENERAL CHARACTER OF EXPENDITURES.	For Year ending December 31, 1902.
Amount brought forward,	$1,324,060 87
High-level Sewer — Construction — Con.	
Contracts — *Con.*	
John W. Bustin & Co., Sect. 57,	53,725 33
Latta & Terry Co., Sect. 58,	78,770 29
H. P. Nawn, Sect. 59,	85,819 84
John W. Bustin & Co., Sect. 60,	49,765 59
Chas. G. Belden & Co., Sect. 61,	83,617 13
E. W. Everson & Co., Sect. 62,	17,145 31
National Contracting Co., Sect. 63,	39,448 71
United States Cast Iron Pipe and Foundry Co., Sect. 64,	5,246 87
E. W. & J. J. Everson, Sect. 66,	94,305 31
Charles Linehan, Sect. 70,	21,387 33
Charles F. Taylor & Co., Sect. 71,	4,206 98
Jones & Meehan, Sect. 72,	8,800 70
National Contracting Co., Sect. 73 (part),	447 10
H. P. Nawn, Sect. 73 (part),	36,348 05
James Russell Boiler Works Co., Sect. 73 (part),	9,823 45
H. P. Nawn, Sect. 74,	21,624 69
E. W. Everson & Co., Sect. 75,	75,030 63
L. P. Soule & Son, Sect. 77, building,	7,613 89
Patrick McGovern, Sect. 78,	5,894 70
Land takings, purchase and recording,	22,803 42
Experts and appraisers,	12,480 64
Legal services,	1,728 60
Claims and allowances on contracts,	18,000 00
Total,	$2,078,095 43
North Metropolitan System — Maintenance.	
Administration: —	
Commissioners, secretary, auditor and assistants,	$1,762 50
Postage, printing, stationery and office supplies,	36 32
Rent, telephone, heating, lighting and care of offices,	190 81
Miscellaneous expenses,	20 52
General superintendence: —	
Engineer and assistants,	4,269 11
Postage, printing, stationery and office supplies,	382 71
Rent, telephone, heating, lighting and care of offices,	638 97
Miscellaneous expenses,	105 78
Deer Island pumping station: —	
Labor,	10,834 54
Coal,	6,772 59
Oil and waste,	261 12
Water,	1,244 40
Packing,	155 08
Repairs and renewals,	488 57
Telephones and office supplies,	222 37
Miscellaneous supplies and expenses,	3,194 62
Salt water suction pipe,	6,457 72
Amount carried forward,	$37,037 73

GENERAL CHARACTER OF EXPENDITURES.	For Year ending December 31, 1902.
Amount brought forward,	$37,037 73
North Metropolitan System — Maintenance — Con.	
East Boston pumping station: —	
Labor,	10,289 99
Coal,	7,192 89
Oil and waste,	221 36
Water,	836 40
Packing,	60 83
Repairs and renewals,	967 92
Telephones and office supplies,	147 77
Miscellaneous supplies and expenses,	2,525 69
Charlestown pumping station: —	
Labor,	10,103 94
Coal,	3,396 57
Oil and waste,	238 98
Water,	441 60
Packing,	81 93
Repairs and renewals,	437 38
Telephones and office supplies,	181 17
Miscellaneous supplies and expenses,	2,239 88
Alewife Brook pumping station: —	
Labor,	3,039 87
Coal,	1,692 71
Oil and waste,	179 51
Water,	212 24
Packing,	26 78
Repairs and renewals,	246 04
Telephones and office supplies,	134 75
Miscellaneous supplies and expenses,	1,052 35
Sewer lines, labor,	14,902 49
Supplies and expenses,	5,260 04
Shirley Gut,	611 25
Charlestown gate-house,	1,971 99
Horses, vehicles and stable account,	3,262 94
Total,	$108,994 99
South Metropolitan System — Maintenance.	
Administration: —	
Commissioners, secretary, auditor and assistants,	$200 00
Postage, printing, stationery and office supplies,	17 34
General superintendence: —	
Engineer and assistants,	1,196 67
Postage, printing, stationery and office supplies,	70 72
Miscellaneous expenses,	16 20
Charles River valley sewer: —	
Sewer lines, labor,	4,684 72
Supplies and expenses,	348 12
City of Boston, for pumping and interest,	60,402 32
Stable account,	39 50
Amount carried forward,	$66,975 59

GENERAL CHARACTER OF EXPENDITURES.	For Year ending December 31, 1902.
Amount brought forward,	$66,975 59
South Metropolitan System — Maintenance — Con.	
Neponset River valley sewer: —	
Sewer lines, labor,	1,301 65
Supplies and expenses,	437 72
City of Boston, for pumping and interest,	23,489 79
Quincy pumping station: —	
Labor,	3,242 12
Coal,	1,798 12
Oil and waste,	49 09
Water,	182 34
Packing,	15 14
Repairs and renewals,	107 70
Telephones and office supplies,	39 09
Miscellaneous supplies and expenses,	1,029 76
City of Boston, for discharge of sewage,	1,000 00
Total,	$99,668 11

(*b*) *Receipts.*

The receipts from the sales of property, from rents and from other sources have been credited as follows: —

	For Year ending December 31, 1902.	From Beginning of Work to December 31, 1902.
North Metropolitan System, — construction,	$469 20	$16,526 73
Neponset River valley sewer, — construction,	–	109 50
High-level sewer, — construction,	1,020 71	1,595 71
North Metropolitan System, — maintenance,	971 08	1,296 10
South Metropolitan System, — maintenance,	22 60	32 60
Metropolitan Sewerage Loans Sinking Fund,	161 67	480 52
Totals,	$2,645 26	$20,041 16

(*c*) *Assets.*

The following is an abstract of the assets of the Sewerage Works, a complete schedule of which is kept on file in the office of the Board: —

Office furniture, fixtures and supplies; engineering and scientific instruments and supplies; horses, vehicles, field machinery, etc.; machinery, tools and other appliances and supplies; real estate connected with works not completed; completed works, including real estate connected therewith.

(d) *Liabilities.*

There are liabilities as follows: —

Current bills unpaid,	$36,892 72*
Due on monthly pay rolls,	1,681 00
	$38,573 72

Amounts on Monthly Estimates, not due until Completion of Contracts or until Claims are settled.

NAME.	Work.	Amount.
North Metropolitan Construction: —		
Jones & Meehan,	Original work, Sect. 44,	$32 00
H. A. Hanscom & Co.,	Sect. 56, held for claims,	200 00
Neponset Valley System: —		
E. W. Everson & Co.,	Original work, Sect. 25,	50 00
Thomas J. Kelley,	Sect. 30,	1,551 94
High-level sewer: —		
Wm. H Ellis,	Sect. 43, wharf at Nut Island,	539 21
Hiram W. Phillips,	Sect. 43, outlet, pipe laying,	3,041 75
Wm. H. Ellis,	Sect. 44,	3,882 07
Latta & Terry Co.,	Sect. 45,	1,386 11
John Cashman,	Sect. 46, embankments,	1,099 23
Charles G Belden & Co.,	Sect. 47,	4,914 37
Charles G. Belden & Co.,	Sects. 48 and 49, embankments,	3,577 90
Charles G Belden & Co.,	Sect. 49, second part,	5,030 89
Charles G. Belden & Co.,	Sect. 50,	4,865 36
National Contracting Co.,	Sect. 52,	21,742 98
National Contracting Co.,	Sect. 53,	13,371 85
National Contracting Co.,	Sect. 54,	4,674 56
H. P. Nawn,	Sect. 55,	4,283 88
J. W Bustin & Co.,	Sect. 57,	3,010 20
Latta & Terry Co.,	Sect. 58,	2,000 00
H. P. Nawn,	Sect. 59,	4,171 84
J. W. Bustin & Co.,	Sect. 60,	2,619 27
Charles G. Belden & Co.,	Sect. 61,	14,755 95
E. W. Everson & Co.,	Sect. 62, reserved for repairs,	100 00
E. W. & J. J. Everson,	Sect. 66,	29,161 71
Charles Linehan,	Sect. 70,	5,095 37
National Contracting Co.,	Sect. 73, contract abandoned,	5,516 17
H. P. Nawn,	Sect. 73, part,	2,884 95
James Russell Boiler Works Co.,	Sect. 73, day work, part,	1,733 55
E. W. Everson & Co.,	Sect. 75,	7,358 35
L. P. Soule & Son,	Sect. 77, Ward St., building,	1,343 63
Patrick McGovern,	Sect. 78,	1,040 24
United States Cast Iron Pipe and Foundry Co.,	Sect. 43, outlet, and Sect. 64,	14,445 39
		$169,480 72

* Miscellaneous current bills of 1902 and those coming in from time to time after January 1, 1903, have since been paid.

Settlement has been made with Elizabeth J. Wright for the sum of $75, but the deed has not yet passed.

On the claims of the following it is impossible to state the amounts due for land and other damages, as suits are now pending in the courts for the determination of the same : —

City of Boston, Henry W. Hunt *et al.*, Peter P. Veale, Margaret Noon, Evangelical Lutheran Church, Charles L. Flint, Jacob Scheffreen, Theodore H. Tyndale, Mary E. Connolly, Mary Rohan and Charles C. Hodgkinson.

VIII. ADMISSION OF OTHER MUNICIPALITIES INTO THE METROPOLITAN WATER DISTRICT.

No municipalities have been admitted into the Metropolitan Water District during the past year. Negotiations have, however, taken place with the authorities of the towns of Milton and Lexington for the admission of these towns into the District, and it is expected that both will be admitted early in the present year.

An arrangement was entered into on February 26, 1902, with the Milton Water Company, by which it was agreed that the Board would furnish water to the company for the water supply of the town of Milton upon the payment of the sum of $5,000, and upon its agreement that the company should maintain meters upon all services and furnish water at meter rates ; and also that the company should pay to the Commonwealth a sum equal to the amount of the annual assessment which the town of Milton would, if it were a part of the Metropolitan Water District, be required to pay in each year. The agreement was made to continue in force until and including the year 1911, or until the company should cease to furnish water to the town, provided the latter event should occur prior to the expiration of said term of years.

IX. CONSUMPTION AND WASTE OF WATER.

The cities and towns supplied wholly or in part by the Metropolitan Water Works have consumed an average of 107,268,000 gallons of water daily, — a consumption per inhabitant of 123 gallons per day. This is an increase of 5,776,000 gallons over that of the year 1901. There was an increase in the consumption per inhabitant, assuming a normal increase of population in the year, of 3 gallons per day.

The average daily consumption of all the cities and towns in the Metropolitan Water District, including Newton and Hyde Park, which are not supplied from the Metropolitan Water Works, was 110,145,000 gallons, and the average daily consumption per inhabitant in these cities and towns was 119.5 gallons.

The population of the Metropolitan Water District, including Swampscott and Milton, is estimated now to be 921,600, and that of the cities and towns now supplied with water from the Metropolitan Water Works is estimated to be 874,200.

The population and consumption of water of the town of Milton are included in the foregoing statistics for the year 1902, but were not included in those for the year 1901.

The principal increase in the consumption of water took place in the month of December, when there occurred an unusually cold period, and when the consumption in one day reached the unprecedented quantity of 151,105,000 gallons. This great increase was largely due to the use or misuse of water in order to prevent the freezing of services on account of defective or improper plumbing, and an average daily consumption of 4,500,000 gallons for the entire year was due to this cause.

The increase of consumption for the entire year was greatest in the southern high-service district, so-called, embracing the high-service district of Boston, Quincy, Watertown, Belmont, and a part of Milton. There was a similar increase, though to a somewhat less extent, in the southern extra-high service district, embracing the high portions of West Roxbury and of Milton, and in the southern low-service district, embracing the low-service district of Boston, with the exception of Charlestown and East Boston. In the other sections there was either a slight increase or a slight decrease in the consumption.

It is to be noted that there was no long-continued period of drought in the summer, such as in some years occasions an excessive consumption of water for the sprinkling of lawns and other like purposes, similar in effect to the demands caused by the freezing weather of winter. The larger part of the summer, on account of the frequent rains, was unusually favorable for a moderate consumption.

There was, however, observed in the early summer a considerable tendency toward the violation of the regulations made for the use of hand hose and automatic sprinklers. A general inspection was

instituted throughout the District for the purpose of marking these violations. By far the largest number of violations of the regulations were found to occur in a very few municipalities, — in the towns of Nahant and Swampscott and the city of Medford. The cases were at once reported to the water officials of the several cities and towns, who generally co-operated with the Board in the enforcement of the regulations. As a consequence, there was later a great decrease in the number of violations, and a considerable decrease in the general consumption from what it otherwise would have been undoubtedly resulted from the enforcement of the regulations.

It was voted by the Board, on February 28, 1902, in accordance with a notice which had been previously given, that the minimum rate to be paid for the use of hand hose in the cities and towns of the Metropolitan Water District for the year 1902 be established at $4.

It was further voted, on November 8, 1902, on recommendation of the chief engineer, "that, until otherwise provided, the minimum rate which shall be approved for the use of hand hose for lawn sprinkling shall be fixed at $4 per annum, such use to be in conformity with the regulations of the Board which were made on August 2, 1901."

The following are the regulations made on August 2, 1901, and now in force relative to the use of hand hose and lawn sprinklers: —

The use of water through hand hose on premises where the water supply is *not* metered shall be restricted to two hours in each day, such use to be had between the hours of 5 and 8 A.M. and 5 and 8 P.M.

The hose must be used with a nozzle not exceeding three-sixteenths of an inch in diameter, and while so used must be held in the hand of a person on the premises of the water taker.

On premises where the water supply *is* metered the above restrictions do not apply, and a lawn sprinkler may be attached to the hose.

Automatic or rotary lawn sprinklers are allowed only in case the water is metered.

The experience and the investigations of the year confirm the Board in the belief that the present annual consumption of water — so much in excess of the estimates made at the time of the passage of the Metropolitan Water Act in the year 1895 — is greater than is necessary, and that there is no inconsiderable waste and misuse of water. It is proper to repeat that this increase in the consumption not only

causes a great increase in the annual expenditures for maintenance and operation, but, more than all, hastens the time when great expenditures must be incurred for new sources of supply, new pumping facilities, new aqueducts, new pipe mains and all other equipment. It is for the interest of every municipality in the District to co-operate with the Board in the adoption of all reasonable measures for the prevention of leakages, waste and misuse of water.

The quality of the water has continued about the same as in the previous year.

X. THE MEASUREMENT OF WATER SUPPLIED TO THE VARIOUS MUNICIPALITIES AND THE PREVENTION OF UNNECESSARY OR IMPROPER USE OR WASTE.

The Metropolitan Water and Sewerage Board was authorized, by chapter 391 of the Acts of the General Court of the year 1902, to construct and maintain such works, and to provide such other means as it should deem necessary for measuring the water supplied to each of the cities and towns in the Metropolitan Water District. The Board was required to report to the General Court in the year 1903 the quantity of water supplied to each of the cities and towns in the District, and whether water is used unnecessarily or improperly therein; and to make recommendations as to the manner in which waste might be prevented, and also as to the manner in which the consumption of water might be considered in the apportionment of the annual assessments among the cities and towns for the construction and maintenance of the Metropolitan Water Works. This Act was approved on May 13, 1902.

The engineers of the Board, in anticipation of the passage of the Act, had already made studies necessary for determining the number and size of meters required for measuring the water supplied to the several cities and towns. It was determined that there would be required nearly or quite 50 meters, in sizes for pipes ranging from 8 inches to 48 inches in diameter. The Venturi meter was selected for the purposes of measurement, as this is the only device which has been practically tested in actual service for measuring and recording the quantity of water flowing through pipes larger than 6 inches in diameter.

Negotiations had also been had with the manufacturers of the meters in relation to the furnishing of the number required. A

definite proposition for the manufacture of the meters was at once requested, and on June 20 a contract for 42 meters was made with the Builders Iron Foundry of Providence, R. I., the only company which manufactures these meters. It was provided in the contract that 40 meters should be delivered from time to time up to November 1, 1902, and it was expected that these could be set and made available for use before the close of the year. This, however, has been found impossible to accomplish. The manufacturers of the meters have encountered the same difficulties which have been experienced by other large manufacturers throughout the country in obtaining the necessary castings, so that but 24 of the meters were received in season to be set before December 15, when the cold weather caused a suspension of all work for the season. A still greater delay has been experienced in the delivery of the registering apparatus, and, in fact, none of the meters were, on January 1, 1903, completed and in service.

Contracts were also made with the Daniel Russell Boiler Works of South Boston for steel chambers in which to place the registering apparatus of the meters.

It has, therefore, been impossible to any considerable extent to measure the water supplied to the various municipalities in the District, and such measurement cannot be fully made for some months to come. The obtaining of the information thus to be acquired, and of the results which are anticipated to follow from the introduction of the various meters, is necessarily antecedent to determining whether water is used in the various cities and towns unnecessarily or improperly, as well as to making any recommendations regarding the manner in which any waste may be prevented, and the apportionment of the annual assessments among the cities and towns.

The contract for the 42 Venturi meters involved an expense of $31,158.45, to which will be added the expense of registering chambers, valves and some other castings, and the labor required in the setting of the meters. It was estimated, before the legislation was passed, that the sum of about $100,000 would be required to accomplish the work.

The facilities afforded for the measuring of water consumed in the town of Stoneham developed the fact that there was an extraordinary consumption of about 125 gallons per day for each inhabitant. As

there was little water used in the town for manufacturing purposes, it was evident that there must exist some leakage or waste which had not been ascertained by the local authorities. By a series of experiments the waste was localized, and leaks in the street mains were found, by which, with the co-operation of the local authorities, the average daily consumption was reduced by more than one-half. Although it is not anticipated that like leakages will be found in general throughout the District, the Board believes that the information to be obtained will lead to the prevention of considerable leakages in various localities of the District. It greatly regrets that it is obliged to postpone, even for a short period, this exceedingly important investigation.

The Act required the Board to report at the present session of the Legislature. The Board has requested that, under the circumstances, further time be granted in which to make a report in accordance with the provisions of the Act, and that the time for report be extended until February 1, 1904.

XI. ELECTROLYSIS AFFECTING IRON PIPES.

Owing to the large amount of construction in progress, it has been found impossible for the engineering force to devote as much attention as was desired to the continued investigation of the injurious action of electric currents upon the iron pipe lines. An arrangement has been made with the Boston Elevated Railway Company, by which, in certain places where the trouble exists, tests have been applied, and by these means measurements are made of the amount of electricity flowing along the pipes, and of the amount flowing from them. It is certain that the destructive action of the electric currents continues, and a remedy must speedily be applied. The investigation of the action of electricity upon the iron pipes will be more vigorously pursued in the future.

XII. RECOMMENDATIONS FOR ADDITIONAL APPROPRIATIONS FOR SEWERAGE WORKS.

In its special report made to the Legislature at the beginning of the year, the Board, inasmuch as the sewerage systems which had been authorized had been completed, or were approaching completion, called attention to the appropriations which would be required

for the completion of the unfinished works, to be largely accomplished, as expected, during the coming year.

The statements and recommendations of the Board were as follows: —

(a) North Metropolitan System.

All of the works which have been authorized to be constructed on account of the North Metropolitan System have been completed, and there appears to be a balance of the appropriations authorized for the purposes under various acts, amounting, on January 1, 1903, to $522.94.

There are, however, several old suits for damages arising on account of the construction of the system, which have not yet been settled. It is estimated that the sum of $250,000 may be required for the settlement of these suits.

(b) South Metropolitan System.

The building of the High-level sewer, which forms a part of the South Metropolitan System, was authorized by chapter 424 of the Acts of the year 1899. The Metropolitan Sewerage Commission, in making up its estimates prior to the recommendation for legislation, estimated that the cost of the work of construction of the High-level sewer, in accordance with the plans which it submitted, would amount to $4,600,000. The Legislature passed the act, in general adopting the recommendations of the Commission, but providing, in section 1 of said chapter 424, that the sewer and the proposed outlet in Boston harbor should not be constructed until plans for the outlet should be considered by the Commission and adopted and approved by the State Board of Health. Subsequently the question of the outlet of the sewer was so considered, and the State Board of Health required that the outlet should be located about 2,000 feet further seaward than was contemplated in the preliminary report. This requirement of the State Board of Health has necessitated the laying of nearly 5,700 linear feet of additional 60-inch pipe, and will involve an expense of about $230,000.

The State Board of Health, in considering the question of sewage disposal into Boston harbor, under a Resolve of the Legislature, recommended, in its report made in the year 1900, that certain areas in the towns of Wellesley, Needham and Weston, though situated upon the north side of the Charles River, should be connected with the South Metropolitan System, or High-level sewer. The Commission accordingly caused an enlargement to be made of the sewer, practically throughout its whole length, which has required an additional expenditure of substantially $75,000.

Section 2 of said chapter 424 provided that the cost of the original investigations and surveys, which had been paid under the original Resolve by the various cities and towns affected, should be repaid to these cities and towns, and that the same should form a part of the cost of construction of the sewer. The repayment of this amount required the sum of $25,677.96.

The Metropolitan Sewerage Commission, in its estimates made prior to the High-level sewer act, provided for the building of a pumping station at Ward Street in Roxbury only large enough for the installation of two pumping engines. The rapid development, however, of the Metropolitan District tributary to this station, and the great increase in the volume of sewage, has convinced the present Board that the time is not far distant when an additional pumping engine will be required, and, consequently, that it was necessary to make a considerable enlargement of the building as originally contemplated. This change has involved an additional expense, estimated at $75,000.

These sums, not contemplated by the original estimates, amount to $405,677.96.

The Board has now endeavored to estimate the amount which will be required to complete the construction of the High-level sewer, in addition to these expenditures caused by changes in the original plans, and they estimate that the amount thus required will be about $1,250,000. For the purpose there is a balance in the treasury of $759,607.70. There will consequently be needed on account of construction the further sum of about $490,000.

The estimates made by the Sewerage Commission, preliminary to the recommendation of the building of the sewer, were made at a time when both labor and supplies were to be obtained at a low price; besides, minor changes have been made which have added to and increased the cost of the work. The additional cost under the later contracts would not seem to be in excess of what might properly be anticipated from the large advance in the cost of labor and supplies.

The land damages on account of the construction of the High-level sewer, for which sums have been in several cases recovered in suits, have considerably exceeded the preliminary estimates of the Metropolitan Sewerage Commission. In order to satisfy all of these claims, it is estimated that the sum of $100,000 will be required.

No additional appropriations have been asked for since the construction of the High-level sewer was originally authorized.

The Neponset River Valley System, which now forms a part of the South Metropolitan System, had been substantially completed; but in the year 1901 the Metropolitan Water and Sewerage Board was directed to extend the sewer a considerable distance, to meet the needs of the city of Newton and the town of Brookline, and the sum of $40,000 was appropriated for this work. The work of extension has now been about completed, and the expense will undoubtedly come within the appropriation; but the payment of some old claims for land damages has so reduced the balance remaining on account of the Neponset River Valley Sewer that a small amount will be required on account of this branch of the South Metropolitan System. This amount is estimated at $4,000.

The Board, therefore, believes that the additional sum of $1,000,000 should be provided for the completion of the South Metropolitan System, as now authorized, made up on account of the following items: —

Extension of the outfall pipes further into Boston harbor, . .	$230,000 00
Provision for additional sewerage districts, ...	75,000 00
Payment for original surveys and investigations, ...	25,677 96
Enlargement of Ward Street pumping station, ...	75,000 00
Completion of construction of High-level sewer, ...	490,000 00
Claims and suits for land damages on account of the construction of the High-level sewer, ...	100,000 00
Claims on account of construction of Neponset River Valley sewer,	4,000 00
	$999,677 96

The Board, therefore, respectfully represents that, in their opinion, authority should be given for the issue of bonds to an amount not exceeding $250,000 on account of the North Metropolitan System, and to an amount not exceeding $1,000,000 on account of the South Metropolitan System.

XIII. NECESSITY OF SEPARATE SEWER SYSTEMS FOR SEWAGE EXCLUSIVELY.

The greater and increasing consumption of water is allied with the established increase in the volume of sewage, — an increase which is growing entirely out of proportion to the anticipations entertained when the Metropolitan Sewerage System was designed. The larger consumption of water is, of course, but one of the factors tending to increase the amount of the sewage which has to be disposed of.

When the construction of the earlier works of the Metropolitan Sewerage District was entered upon, the combined system, so-called, prevailed. The sewers at that time collected not only the sewage proper, that is, the domestic and manufacturing wastes, but also, in combination with this sewage, the rainfall. The proportion of rainfall thus provided for and collected by the intercepting sewers of the Metropolitan System was fixed at the lowest amount regarded as permissible under the prevailing conditions, and was generally equivalent to a depth of 0.01 of an inch of rainfall in an hour upon the territory served by the sewers. In this way the Metropolitan sewers collected from the contributing areas the sewage mingled with rainfall. Overflows were provided, however, in the contribut-

ing sewers, to be used in times of storms or larger rains, by which the combined sewage and rainfall in excess of the capacity of the intercepting sewers was discharged at outlets into rivers or streams.

As the population has increased, especially in congested districts, the proportion of the element of sewage to the rainfall which overflows into the streams has greatly increased, and has frequently created a most unsanitary and objectionable condition. The congestion and increase in population have also tended to call for the building of larger intercepting sewers, and to make the sewers already constructed, if not inadequate to the present demands, at least inadequate to provide for the period of time for which they were designed. The combined system thus developed would call for the construction of sewers to a size and extent which in their cost would be almost prohibitive.

Both sanitary and economical considerations have, therefore, called for the building of separate sewers, so-called, that is, sewers in which sewage proper only should be received; and that other works should be constructed by which all the rainfall may be conveyed in separate conduits to the streams.

The High-level sewer, now in process of construction, which will provide for the southern portion of the Metropolitan Sewerage District, is designed to receive only sewage. The dimensions and consequent cost of this sewer, if based upon the combined system, would have been such as to have rendered the undertaking doubtful, if not impossible.

The combined system in general prevails in the cities of Cambridge, Somerville, Chelsea, Everett, and in the town of Brookline, as well as in considerable portions of the city of Boston, although in these localities there have been constructed some sewers upon the separate system.

It is apparent, therefore, that in substantially all cases sewers upon the separate system only should be connected with the High-level sewer. Such works as are necessary in the various cities and towns to provide for the disposal of the rain water by other methods should be speedily entered upon, so far as necessary to that end. By thus reducing the work which the Metropolitan sewers will be called upon to do, their capacity will be effectively increased, and the period will be prolonged at the end of which enlargements and duplications would otherwise be necessary. The necessity, also, of

providing for the disposal through the main sewers of the entire amount of the sewage of the various contributory regions, and the doing away with all overflow of sewage, however diluted, into the rivers and streams in times of heavy rainfall, is demanded by every consideration for the sanitary well-being of the Metropolitan District.

XIV. INDUSTRIAL CONDITIONS.

The industrial conditions which have recently prevailed have largely affected the construction of the various works, and have brought considerable difficulties both to the Board and to the contractors.

There has been an advance in prices of almost all classes of materials and supplies which have entered into construction. This has been seen in the case of the prices charged for iron pipes, of which 21,200 tons were purchased during the past year. Pipes were purchased for the Water Works in the year 1898 as low as $16.60 per ton, while rates as high as $27.70 per ton were required in the past year for large quantities purchased. An advance of $4 to $5 per ton was made in the past year over prices of the preceding year.

There has been a like rise in prices for iron castings and for steel work, of which large quantities have been required for bridges and other purposes, and also for all the materials to be used in the construction of the various buildings which the Board is now called upon to construct.

It has, moreover, frequently been impossible to obtain the materials contracted for, especially iron and steel work, in the times fixed by the contracts; and much trouble has resulted, both to the contractors of the Board and to the Commonwealth, on account of the failure to make due deliveries.

The strike of the anthracite coal miners has made it difficult at periods to obtain a sufficient supply of coal with which to operate compressor plants, engines and locomotives used by the various contractors; and the cost of the work has been materially increased by the great rise in the cost of coal, the prices paid being at times between 200 and 300 per cent. greater than in previous years.

Considerable difficulty has also been experienced in obtaining sufficient cement, particularly Portland cement, and masonry construction has been at times seriously delayed on this account. This difficulty has been somewhat due to the shortage of coal, but has

arisen mostly on account of the unprecedented demand for cement for construction purposes all over the country.

The wages paid for labor have been higher than those paid for several years previous, and not infrequently upon the contracts it has been at times found difficult to obtain the number of men required. Prices for skilled labor have most notably advanced.

The great public works which are in process of construction throughout the country have also made large demands upon the engineering forces, and many members of the corps employed by the Board have been from time to time called to positions of larger responsibility elsewhere.

As a consequence of these conditions, the cost of work has at times necessarily exceeded the prices and estimates figured upon the basis of former conditions, both by the Board and its contractors, and it has been made much more difficult to complete the various undertakings in the times set for their fulfilment.

XV. FUTURE WORK.

The amount of construction both upon the Metropolitan Water Works and the Sewerage Works has probably reached its maximum during the year 1902. The expenditures for construction of Water Works have been $3,657,389.30, and for the Sewerage Works the expenditures for construction have been $2,167,964.80.

There will, however, be required a large amount of construction in both departments during the coming year.

The cost of maintenance, which has been $294,045.14 for the Water Works and $208,663.10 for the Sewerage Works, will undoubtedly increase from year to year.

It is hoped that the Weston Aqueduct and the Weston Reservoir will both be substantially completed during the coming year, as well as the relocation of the Central Massachusetts Railroad. The building of the Wachusett Dam and Reservoir will be prosecuted as vigorously as in the past year. The construction of the terminal chamber, the various gate-houses and siphon and screen chambers, upon the Weston Aqueduct, will be carried on.

It is expected that the High-level sewer will be largely completed, although much difficult work is still to be done, especially in the laying of the submarine pipes for the outlets off Nut Island. A large pumping station, with its engines and other equipment, is to

be built at Ward Street in Roxbury, and a considerable building for the purposes of a screen chamber on Nut Island is to be constructed.

Considerable attention will necessarily be devoted to the abatement of sources of pollution of the water supply, and thorough investigations will be made as to the unnecessary and improper consumption of water and the stopping of waste and leakages.

The report of the Chief Engineer relating to the Metropolitan Water Works, and the report of the Engineer of the Sewerage Works, are herewith submitted.

Respectfully submitted,

HENRY H. SPRAGUE.
HENRY P. WALCOTT.
JAMES A. BAILEY, Jr.

Boston, February 26, 1903.

REPORT OF THE CHIEF ENGINEER.

To the Metropolitan Water and Sewerage Board.

GENTLEMEN: — The following is a report of the operations of the Engineering Department of the Metropolitan Water Works for the year ending December 31, 1902.

ORGANIZATION.

Owing to ill health, Desmond FitzGerald, who has held important positions on the Boston and Metropolitan Water Works, continuously, for twenty-nine years, was obliged to discontinue work on October 17, and later tendered his resignation as engineer of the Sudbury Department, which was accepted on November 15. Mr. FitzGerald has always been foremost in advocating and adopting measures to raise the standard of water supplies, and his work in connection with the better preparation of reservoirs, the biological examination of waters and the protection of waters from pollution is well known to engineers, and has been of great value to the city of Boston and the Metropolitan Water District.

As the work remaining to be done in the Sudbury Department is chiefly the maintenance of the works, no one has been employed to take Mr. FitzGerald's place, but the duties of the department have been divided, the charge of the storage reservoirs and other works on the Sudbury and Cochituate watersheds, with the exception of the improvements at Lake Cochituate, and of the Sudbury and Cochituate aqueducts, being given to Charles E. Haberstroh, the assistant superintendent; and the charge of the improvements at Lake Cochituate, of the Boston office, including the work of the biological laboratory, of the determination of the sources from which water shall be drawn through the aqueducts and of records and reports, being given to Charles W. Sherman, division engineer, who was Mr. FitzGerald's principal assistant in Boston. Mr. Sherman was also given temporary charge of Chestnut Hill Reservoir and grounds, which you have already voted to transfer to the Distribution Department on January 1, 1903.

Another important change in the personnel of the force was caused by the resignation of Alfred D. Flinn, principal office assistant, which took effect October 6, to accept the position of managing editor of the "Engineering Record." By Mr. Flinn's resignation the State has lost a very valuable and efficient assistant. His place has been filled by the transfer of Frank T. Daniels, division engineer of the Metropolitan Sewerage Works, to the Metropolitan Water Works.

The list of assistants reporting directly to the Chief Engineer at the end of the year is as follows: —

Dexter Brackett, . . .	*Engineer of Distribution Department.*
Thomas F. Richardson, . .	*Engineer of Dam and Aqueduct Department.*
Hiram A. Miller, . . .	*Engineer of Reservoir Department.*
Horace Ropes, . . .	*Engineer of Weston Aqueduct Department.*
Charles E. Haberstroh, .	*Assistant Superintendent, Sudbury Department.*
Charles W. Sherman, . .	*Division Engineer, Sudbury Department.*
Frank T. Daniels, . . .	*Principal Office Assistant.*
John N. Ferguson, . . .	*Office Assistant.*

Joseph P. Davis, A. Fteley and Hiram F. Mills have continued as consulting engineers.

John W. Lynch has continued in direct charge of the pumping stations at Chestnut Hill, and in general charge of the mechanical work at all other pumping stations of the Distribution Department.

George E. Wilde has continued as assistant superintendent in the Distribution Department, in immediate charge of the maintenance and operation of the pipe lines and other works within the Metropolitan District, with the exception of the pumping stations, and is also engaged much of the time upon the work of construction.

At the beginning of the year the engineering force, including both those engaged upon the construction and maintenance of the works, numbered 158, and at the end of the year 196; and during the year fluctuated from a minimum of 155, in February, to a maximum of 236, in August.

In addition to the engineering force, which included the engineers engaged upon the inspection of the work, other inspectors have been employed upon masonry, earthwork and pipe laying. The maximum number so employed at any one time during the year was 27.

Gangs of men, under the immediate direction of foremen and under the general direction of the engineers, have been employed

from time to time to do minor work, the more important items of which were digging a narrow channel in the bed of the Nashua River below the Lancaster Mills, making improvements at Lake Cochituate, and laying Venturi meters and raising pipes in the Metropolitan Water District.

There has also been a maintenance force, averaging 179, employed at the pumping stations and in connection with the maintenance of reservoirs, aqueducts, pipe lines, swamp ditches and other work.

Force Employed on Works.

The force employed upon the works in 1902 was considerably larger than the force employed in 1901, owing to the greater amount of contract work.

The largest force employed upon the works at any one time during the year was for the week ending August 2, as follows: —

	Men.		Horses.	
Contractors' force: —				
Reservoir Department,	1,167		156	
Dam and Aqueduct Department,	691		63	
Sudbury Department,	159		36	
Weston Aqueduct Department,	1,334		252	
Distribution Department,	543	3,894	59	566
Day-labor force, construction,		108		8
Engineering force, including engineer inspectors and those engaged upon maintenance,		229		-
Inspectors not engineers,		23		-
Maintenance force, not including civil engineers,		196		-
		4,450		574

Arrangement of Report.

In continuing this report, it is the purpose to separate the work charged to the construction account from that charged to the maintenance account; but, as the work of construction and maintenance is supervised by the same principal engineers, and in very many cases the assistants are engaged upon both classes of work, it is not feasible to make a complete separation.

CONSTRUCTION.

CONTRACTS.

A detailed statement of the contracts made and pending during the year is given in Appendix No. 1. The following statement gives a summary of all the contracts charged to construction from the beginning of the work to the end of 1902: —

PORTION OF WORK.	Number of Contracts.	Approximate Amount.
Wachusett Reservoir,	26	$2,548,297 86
Wachusett Dam,	4	1,634,263 78
Relocation Central Massachusetts Railroad,	5	454,388 35
Wachusett Aqueduct and Clinton sewerage,	19	1,516,259 67
Sudbury Reservoir, the portions of contracts not performed at the time they were assumed from the city of Boston,	11	583,220 54
Sudbury Department, reservoir, filter-beds, pipe lines and improvement of Lake Cochituate, Metropolitan Water Works contracts,	22	956,508 17
Weston Aqueduct and Reservoir,	23	2,061,994 45
Distribution Department, including pipes, valves and special castings purchased for other departments,	156	4,462,457 91
Totals,	266	$14,217,390 73

Number of contracts made in 1902,	37
Number of contracts completed in 1902,	26
Total number of contracts made to December 31, 1902,	266

Amount of contracts made and assumed in 1896, including only the portions of contracts assumed from the city of Boston, performed under the direction of the Board,	$3,893,934 31
Amount of contracts made in 1897,	1,271,960 64
Amount of contracts made in 1898,	743,748 75
Amount carried forward,	$5,909,643 70

Amount brought forward,	$5,909,643 70
Amount of contracts made in 1899 (approximate),	2,291,614 62
Amount of contracts made in 1900 (approximate),	1,751,176 10
Amount of contracts made in 1901 (approximate),	2,794,142 95
Amount of contracts made in 1902 (approximate),	1,470,813 36
	$14,217,390 73
Amount of contracts completed to December 31, 1901,	$7,654,798 39
Amount of contracts completed in 1902,	734,985 16
	$8,389,783 55
Amount of 35 contracts unfinished December 31, 1902 (approximate),	6,339,607 18
	$14,729,390 73
Deduct for work done on 11 Sudbury Reservoir contracts by city of Boston,	512,000 00
	$14,217,390 73
Value of work done by contract to December 31, 1896,	$2,061,910 38
Value of work done by contract from January 1, 1897, to December 31, 1897,	2,647,063 53
Value of work done by contract from January 1, 1898, to December 31, 1898,	703,141 71
Value of work done by contract from January 1, 1899, to December 31, 1899,	1,206,791 72
Value of work done by contract from January 1, 1900, to December 31, 1900,	927,034 80
Value of work done by contract from January 1, 1901, to December 31, 1901,	1,067,540 70
Value of work done by contract from January 1, 1902, to December 31, 1902,	2,940,261 46
	$11,553,744 30
Value of work remaining to be done on 35 unfinished contracts December 31, 1902 (approximate),	2,663,646 43
	$14,217,390 73

In the case of all contracts completed up to the present time final settlements have been made without any legal controversy, and there have been no strikes of employés which went beyond an incipient stage or lasted more than two or three days.

RESERVOIR DEPARTMENT.

HIRAM A. MILLER, *Department Engineer.*

The organization of the engineering force has been substantially the same as during the previous year. Charles E. Wells, division engineer, has continued in charge of the inspection of the removal of soil from the Wachusett Reservoir and the supervision of the contractors engaged on that work. Charles A. Bowman, division engineer, has continued in charge of the force reports, measurements, estimates and miscellaneous engineering work connected with the removal of soil, and of divers small amounts of engineering work of a general character. Harry J. Morrison, division engineer, has continued in charge of the work at the North Dike, and has been placed in charge of the construction of the relocation of the Central Massachusetts Railroad, from a point a short distance east of the North Dike to the connections with the Worcester, Nashua & Portland Division of the Boston & Maine Railroad. Moses J. Look, assistant engineer, had charge of the work connected with the relocation of roads and railroads at West Boylston and Oakdale until April 12, when the work was divided, Mr. Look being assigned to the work at Oakdale, and Ernest H. Baldwin, assistant engineer, being placed in charge of the work at West Boylston. On May 15 Mr. Look was transferred to the Dam and Aqueduct Department, Mr. Baldwin being placed in charge of the work at Oakdale, and Arthur W. Tidd, assistant engineer, in charge of the work at West Boylston. All of the above engineers reported directly to the department engineer.

The total engineering force in this department has varied from 47 to 72.

The main office of this department is in Clinton. Four branch offices, one near the North Dike in Clinton, one at Sawyer's Mills in Boylston and two in West Boylston, have been continued throughout the year, and another has been established in Oakdale.

NORTH DIKE.

Work upon the North Dike has been in progress during the year under the contractors, Nawn & Brock, Long & Little and the Newell & Snowling Construction Company.

The work done by each will be described more fully under the head of Contracts. The total amount of work done during the year, with the total amount to date, is given in the following table: —

	To December 31, 1901.	For the Year 1902.	Total to December 31, 1902.
Soil and earth excavated from main cut-off trench (cubic yards),	499,856	-	499,856
Soil and earth excavated from secondary cut-off trench (cubic yards),	42,033	-	42,033
Sheet piling driven (linear feet),	5,245	-	5,245
Surface of rock uncovered and treated at bottom of main cut-off trench (square feet),	77,250	-	77,250
Soil from reservoir deposited in cut-off trenches and in the dike (cubic yards),	3,418,839	1,089,627	4,508,466
Earth and gravel taken from borrow pits and deposited in the dike (cubic yards),	98,355	90,779	189,134
Earth excavation for the construction of a small dike in Coachlace Pond (cubic yards),	19,172	-	19,172
Drain pipe laid at the toe of the westerly portion of the dike (linear feet),	7,083	-	7,083
Screened gravel on the water slope of the easterly portion of the dike as a foundation for riprap (cubic yards),	-	4,435	4,435

The present condition of the dike, relative to its completion, is as follows: —

At the beginning of 1902 the excavation of the main and secondary cut-off trenches, the filling with soil of the secondary cut-off trench and the driving of the sheet piling had been completed, and the filling of the main cut-off trench had been substantially completed. The work of rolling soil in 6-inch layers above the main cut-off trench and of depositing soil in 7½-foot layers has continued throughout the year and is completed. Of the soil filling, which constitutes the principal part of the dike, 4,508,466 cubic yards have been deposited, which is 91 per cent. of the total amount required, as at present estimated. All the soil required, except about 2,000 cubic yards, has been deposited in the easterly portion of the dike and all in the northeasterly 2,400 feet of the westerly portion.

Work has continued on the embankment of earth and gravel on the water slope of the dike.

The depositing of screened gravel as a foundation for the riprap on the easterly portion of the dike was commenced on May 30 and continued throughout the year.

The depositing of riprap on the easterly portion of the dike has been completed for 1,320 feet from its easterly end.

A day-labor force was engaged most of the time during the first half of the year in consolidating the soil in the dike by saturating it with water, continuing the work which was in progress at the end of the previous year. Water was pumped day and night from Sandy Pond upon the easterly portion of the dike, from the beginning of the year until March 22, and from May 19 until June 30. Special care was taken during the first period of pumping to saturate the soil rolled in 6-inch layers, and the embankment to the extent of 4½ acres was flooded for about twelve weeks. This required the construction of about 6,050 linear feet of small dikes, from 1 to 6 feet in height, forming small basins into which the water could be pumped. During the second period of pumping the water was used entirely on the northerly slope of the dike. The amount of water pumped upon the easterly portion of the dike was approximately 68,000,000 gallons. Water was pumped upon the westerly portion of the dike during the day time from February 24 to May 19, except when the pump was out of service for needed repairs.

Measurements made to determine the extent to which the soil was consolidated by the saturation indicated that it had already been so well consolidated that the saturation did not have any large effect. On the portions of the embankment where the soil had been rolled in 6-inch layers and it had an average depth of 51 feet, the settlement, as shown by measurements at 22 points, ranged from 0.06 to 0.26 of a foot, and averaged 0.15 of a foot. On the portions of the embankment where the material had been deposited in 7½-foot layers without rolling and it had an average depth of 40 feet, the maximum settlement, as shown by measurements at 186 points, was 1 foot, and the average settlement 0.47 of a foot.

A day-labor force was also employed in opening a quarry a short distance east of the easterly end of the dike, in order to determine the suitability of the rock for use in slope paving on the water slope of the dike; but the decision to build the relocation of the railroad through the same ledge rendered further investigation unnecessary.

Other day-labor work at the North Dike consisted of constructing a wooden box culvert under the temporary road near the northerly toe of the dike, a cart road around the end of the easterly portion of the dike, and gages at Sandy and Coachlace ponds; digging test

WACHUSETT RESERVOIR — HEAVY RIPRAP AND GRAVEL FACING ON THE NORTH DIKE.

pits and drainage ditches; sowing grass seed and rye on the finished portion of the dike, and mowing and burning weeds.

The maximum day-labor force employed at the dike was 42 men and 8 horses, for the week ending January 11.

Relocation and Construction of Roads.

Considerable progress has been made on surveys and studies for the relocation of roads at the upper end of the reservoir, to take the place of those discontinued.

A determination of changes in the grade of the road from Clinton to West Boylston, on and in the vicinity of the North Dike, and for the relocation of a small portion of the South Meadow Road, both made necessary by the relocation of the Central Massachusetts Railroad, was made by the Board and agreed to by the County Commissioners of Worcester County on July 22.

Nawn & Brock, under their contract for the relocation of the railroad, constructed the new highway across the dike and made the necessary changes in the existing highway where it is to pass under the railroad bridge, and also constructed the short piece of the relocated South Meadow Road. Work was commenced on August 23, and the highways were nearly completed at the end of the year, 1,660 feet having been completed and accepted.

Meskill Brothers & Leahy constructed a portion of the road located last year across the reservoir in West Boylston, connecting Worcester Street on the southerly side and Sterling and Lancaster streets on the northerly side. On the southerly side of the reservoir they constructed 1,173 feet of the main road, also a connection 214 feet in length, between the main road and Prospect Street, near the South Boylston station. On the northerly side they constructed 1,125 feet of road-bed along Howe and Fletcher streets, also the proposed extension toward Oakdale for 431 feet, making a total of 2,943 feet of road-bed made ready for the broken stone surfacing.

A second and much more extensive slip of the soil used for dressing the slopes of the Boylston Street embankment in Clinton, between Oak and Wilson streets, occurred during the heavy rain of December 15, 1901, which made it desirable to extend the system of drainage built in 1901 in a portion of this embankment, so as to include not only the additional places where the soil had slipped, but also all of the higher portions of the embankment where the soil

had not slipped. The drainage of the embankment was accomplished by digging trenches in the clayey material and filling them with stones, and a foot of coarse sand or gravel was placed over the clayey material where the soil slipped, before replacing the soil upon the surface. In addition to this drainage of the slopes, a drain consisting of a 5-inch sewer pipe covered with screened gravel was laid on the westerly side of Boylston Street, from Oak Street, for the greater portion of the distance to Wilson Street, to intercept the water draining through the broken-stone surfacing of this street, and divert it through drains to the river. A drain of the same kind was also laid on the easterly side of River Street at the foot of the slope. A guard fence was rebuilt where it had been displaced, the slopes were re-seeded and the grass was cut.

The extent of this work, which was all performed by the day-labor forces, is indicated by the following statement: —

Slopes resurfaced (square feet),	16,000
5-inch sewer pipe drain constructed (linear feet),	2,370
Stone drains constructed on slopes (linear feet),	3,440

On land of Thomas Mackesy 148 feet of 24-inch sewer pipe were laid, to conduct the water from the end of the culvert at the highway through his field to the stock pond.

So far as necessary, the discontinued highways through the reservoir have been kept in a condition to render them reasonably safe for travel. Some of the repairs necessary have been made by the contractors and some by the day-labor forces of the Board.

Much other minor work has been done by the day-labor forces, such as the replanking of bridges, repairs to paving connected with the road culverts where in or near the reservoir, the sowing of grass seed on the slopes of embankments, digging of test pits and making of wash-drill borings at the sites of proposed road bridges across the rivers, and the setting of stone bounds on the road locations.

The maximum day-labor force employed in connection with the work upon the roads was 44 men and 10 horses, for the week ending May 10.

Considerable work has been done by the engineers in making plans and specifications for the location and construction of new roads towards the upper end of the reservoir and at the North Dike, and for the discontinuance of roads at West Boylston village and at

Oakdale. A plan for submission to the County Commissioners of the proposed relocation of the roads on the northerly side of the reservoir, from West Boylston village to Oakdale, and through Oakdale to Holden and Newton streets, has been made.

Removal of Soil.

Work upon the removal of soil from the reservoir has been in progress during the year under the contractors, Nawn & Brock, Long & Little, Meskill Brothers & Leahy, and George M. Atkins & Co. An additional contract with Bruno, Salomone & Petitti was made toward the end of the year for the removal of nearly all the soil in the upper portion of the reservoir not included in previous contracts. More detailed information in regard to each contract will be found under the head of Contracts.

The total amount of soil removed and to be removed from the Wachusett Reservoir is at present estimated to be about 6,900,000 cubic yards, from approximately 4,200 acres. Of this, the total amount removed from the reservoir in previous years was 3,588,648 cubic yards, from 2,116 acres; in 1902, 1,246,931 cubic yards were removed from 715 acres, — making a total from the beginning of the work to the end of 1902 of 4,835,579 cubic yards, or 70 per cent. of the total as at present estimated, removed from 2,831 acres.

The existing contracts provide for the removal of substantially all soil except a comparatively small quantity in and along the margins of the Oakdale mill-pond at the extreme upper end of the reservoir, and a somewhat larger quantity in the easterly portion of the reservoir which is to be used in connection with the construction of the South Dike.

Of the soil removed to the end of 1902, 172,879 cubic yards were used for road embankments, 17,720 cubic yards for shallow-flowage areas, 65,715 cubic yards for railroad embankments, and 4,508,466 cubic yards for the North Dike. There have been, during the year, 33,851 cubic yards of earth used to cover deep muck to the depth of about 1 foot; this amount, added to the 49,893 cubic yards used for the same purpose during previous years, gives a total of 83,744 cubic yards.

During the year, with the exception of a small portion which has been loaded into dump carts and hauled directly to the dike, the soil excavated and deposited in the dike has been loaded into cars, or

first loaded into carts and then dumped into cars at the dumping platforms. The soil has been hauled to the dike by locomotives over the line of double track which passes by the South Clinton station to the easterly portion of the dike, over a single track line of railway along Cunningham's Brook, entering the westerly portion of the dike near its centre, and over another single track line entering the westerly portion of the dike at the westerly end. A large portion of the soil hauled into the westerly portion of the dike on the railway entering the dike at the westerly end was loaded into cars on the intervale above Sawyer's Mills, and hoisted to the top of the bluff by an incline in that locality.

The plant employed on soil removal, exclusive of carts, included 30.7 miles of 3-foot-gage track, 22 10 to 16 ton locomotives, 700 2½ to 3½ cubic yard dump cars, and 1 70 horse-power hoisting engine.

The soil deposited in the road embankment at West Boylston village and in the railroad and shallow-flowage embankments at Oakdale has been hauled in wagons and carts.

A day-labor force under the direction of the engineering force performed the following work: —

The wood and brush were cleared from about 210 acres of the upper end of the reservoir site, including a strip 50 feet wide along the shore. The dam formerly belonging to the West Boylston Manufacturing Company on the Stillwater River was torn down, to lower the water and reduce the current through the head-gates, which collapsed during the spring floods. The telephone line was extended from West Boylston to Oakdale. Considerable work was done tearing down and clearing up around the mill formerly belonging to the West Boylston Manufacturing Company. The logs from the upper end of the reservoir, containing approximately 325,000 to 350,000 feet of lumber, were sawed. The gates and dam at the Clarendon Mills have also been cared for, and ditches and water courses through the margins of the reservoir have been maintained. The small trees and shrubs which have sprung up on the area from which soil has been removed have been pulled or grubbed, and the brush has been mowed on the 50-foot strip along the shore of the reservoir, where it had previously been cleared.

In addition to the engineering work connected with the estimates and inspection of the removal of soil, the following work has been done: —

For the guidance of the inspectors, the organic matter in 554 samples of soil has been determined. A new channel for Muddy Brook, 1.3 miles in length, along one side of the deep muck which it is proposed to cover, has been located. The limit along the margin of the reservoir of the area from which soil is to be removed has been staked out for 4.7 miles. Preliminary estimates of quantities and cost, plans, specifications and one of the contract drawings were made for Contract No. 257. Topographical surveys and plans have been made of 69 acres of shallow-flowage and steep slopes along the margins of the reservoir, and cross-sections have been taken and plotted. The proper treatment of the shallow-flowage areas and steep slopes has been studied. There have been 150 construction benches established.

Relocation of Railroads.

Under the agreement made between the Board and the Boston & Maine Railroad on April 3, 1902, the line for the relocation of the Central Massachusetts Railroad around the reservoir was definitely determined.

The new location leaves the present location at the bridge over the New York, New Haven & Hartford Railroad in West Berlin and swings to the north, running in a fairly direct line to a crossing over the South Branch of the Nashua River about 800 feet below the Wachusett Dam. After crossing the river the line curves and passes close to the northerly end of the dam, and along the margin of the reservoir to the easterly end of the North Dike; thence it follows along the dike a short distance below its crest, and curves to a junction with the Worcester, Nashua & Portland Division of the Boston & Maine Railroad about half a mile beyond the dike. The length of the new line to this junction is 3.92 miles. From the junction, for a distance of about 4.40 miles, to a point about half a mile north of the present crossings of the railroads at Oakdale, the double tracks of the Worcester, Nashua & Portland Division are to be utilized, and no new construction is required; but at Oakdale it is necessary not only to lay new tracks to connect with the Central Massachusetts Railroad, but also to change the location of the tracks of the Worcester, Nashua & Portland Division, in order that a suitable connecting curve may be made between the two railroads. These changes, together with the flowage of some of the railroad lands at Oakdale, require a relocation of freight tracks, freight and passenger stations

and other appurtenances of the railroad at this place. The length of the relocation in Oakdale from the most northerly point to the junction with the existing tracks of the Central Massachusetts Railroad is 0.55 of a mile. The total length of the new route is 8.87 miles, only one-third of a mile longer than the existing route through the reservoir.

In addition to the main track, a branch track, commonly known as the Y, is provided, leaving the main track near the easterly end of the dike and curving to a junction with the Worcester, Nashua & Portland Division north of the dike, so that outward trains from Boston can be run directly to the station at Clinton. The length of this Y branch, which is located most of the way on the outer slope of the dike, is about four-fifths of a mile.

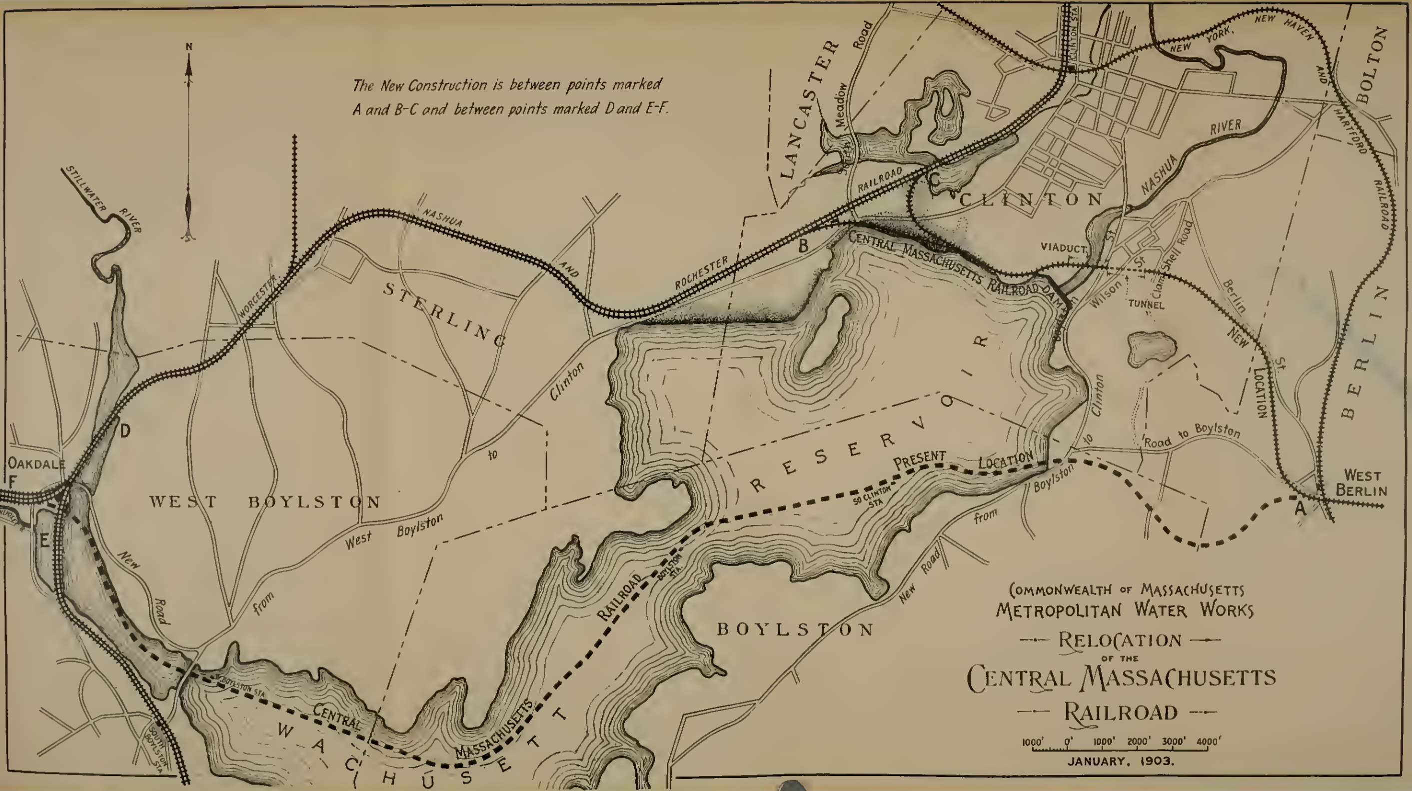
In order to carry the railroad past the reservoir without making a long detour, it was necessary to locate it where there would be unusual difficulties in construction. In a length of 1 mile near the dam there are required a tunnel 1,110 feet long; a viaduct 917 feet long for crossing the valley of the river, with a maximum height of 133 feet; and 1,500 linear feet of rock cut, having a maximum depth on centre line of 56 feet.

In order to avoid grade crossings, the railroad is to be carried over a road in Berlin and another in Clinton on steel bridges, and similar bridges are to be built to carry two roads over the railroads at Oakdale. An end span of the viaduct also crosses another road in Clinton.

The highway which runs along the North Dike has been raised to pass over the Y track, and it is the intention to use a wooden bridge for the highway at this place for the present, as it is located on filled ground, which will not permit the use of masonry and steel.

The agreement with the Boston & Maine Railroad provides that the work of constructing the relocation of the railroad shall be done by and at the expense of the Board, and the Board is also to do the grading incidental to the construction of the Y branch, but is to be reimbursed for the expense of this work by the Railroad. The Railroad has made the designs and inspected the material for the bridges and will inspect their erection. Arrangements have been made with the Railroad to furnish the materials for and build the tracks.

Delay in completing the negotiations for the relocation of the railroad rendered it imperative that the work of construction should be



The New Construction is between points marked A and B-C and between points marked D and E-F.
COMMONWEALTH OF MASSACHUSETTS
METROPOLITAN WATER WORKS
RELOCATION
OF THE
CENTRAL MASSACHUSETTS
RAILROAD
1000' 0' 1000' 2000' 3000' 4000'
JANUARY, 1903.
N
STILLWATER RIVER
WORCESTER NASHUA AND ROCHESTER RAILROAD
STERLING
LANCASTER
Meadow Road
CLINTON
CLINTON STA
NEW YORK, NEW HAVEN AND HARTFORD RAILROAD
BOLTON
NASHUA RIVER
VIADUCT
DAM
TUNNEL
CENTRAL MASSACHUSETTS RAILROAD
Berlin St.
NEW LOCATION
BERLIN
WEST BERLIN
Road to Boylston
Clinton to Boylston
Wilson St.
Clamshell Road
PRESENT LOCATION
SO CLINTON STA
RESERVOIR
WACHUSETT
BOYLSTON STA
BOYLSTON
New Road from Boylston
WEST BOYLSTON
Clinton to West Boylston
from West Boylston
New Road
OAKDALE
SOUTH BOYLSTON STA
A
B
C
D
E
F

carried on vigorously, in order not to delay the storage of some water in the reservoir for the maintenance of the supply to the Metropolitan Water District. Plans were therefore completed and the work placed under contract at the earliest possible moment.

For construction purposes the work was divided into four sections, the first three covering the portion from West Berlin to the junctions with the Worcester, Nashua & Portland Division, and the fourth including all the work at Oakdale.

Sections 2 and 3 were very intimately connected with the work at the dam and dike, respectively; and on this account, and because of the facilities which the contractors for these works had for starting upon the work promptly and prosecuting it rapidly, arrangements were made with the McArthur Brothers Company for constructing Section 2, and with Nawn & Brock for constructing Section 3.

The contract with the McArthur Brothers Company, which covered a large amount of work, was dated April 18, 1902, and required the completion of the work within one year from the date of the contract. The other contracts, including the contract for the steel viaduct and bridges, were made as soon afterward as possible, and all of them are by their terms to be completed on or before April 1, 1903, or at an earlier date.

Sections 1 and 2 were placed in charge of the engineer of the Dam and Aqueduct Department, and sections 3 and 4 in charge of the engineer of the Reservoir Department, as this division gave each the work within the territory under his charge. A further report of the work done upon sections 1 and 2 will be included subsequently, in connection with the work performed by the Dam and Aqueduct Department. The details of the contract work done in the Reservoir Department on sections 3 and 4 will be found under the head of Contracts.

Day-labor forces have performed the following work in connection with the relocation of railroads: —

The foundations of the abutments of the arch over the Quinepoxet River, which had been nearly undermined by the current of water, were grouted, and further undermining was prevented by paving under and below the arch; this work required 68 barrels of Portland cement, 626 cubic yards of paving and 5,000 feet B.M. of spruce sheeting. The covered channel formerly used by the West Boylston Manufacturing Company to divert the water from the Quinepoxet

River into the Oakdale mill-pond was partially filled. The slope of the railroad embankment near the site of the West Boylston Manufacturing Company's dam across the Quinepoxet River has been riprapped.

The maximum day-labor force employed was 21 men and 7 horses, for the week ending September 13.

In addition to the engineering connected with the execution of the work, the engineers have prepared specifications and contract plans for the relocation of the railroad in the vicinity of the North Dike and at Oakdale. Plans and estimates were made for repairing and improving the wing walls of the arch bridges on the Worcester, Nashua & Portland Division over the Stillwater and Quinepoxet rivers. A plan was made of property at Oakdale to be deeded from the Commonwealth to the Railroad, and of other property to be deeded from the Railroad to the Commonwealth, on account of the change in the location of the railroads.

Contracts, Wachusett Reservoir.

Contract 166, Nawn & Brock.

Excavating Soil from Section 6 of the Wachusett Reservoir, and building the Easterly Portion of the North Dike in Boylston, Clinton and West Boylston.

On June 13, 1899, a contract was made with Nawn & Brock for the completion of the easterly portion of the North Dike, with the exception of the slope paving or riprap. The material for this purpose, with the exception of comparatively small amounts of sand and gravel, was to be obtained by removing the soil from some 1,700 acres, known as Section 6 of the Wachusett Reservoir.

The contractors have prosecuted their work during the year in substantially the same manner as formerly, hauling the soil from all areas up their double-track railway to the dike. On the intervale and other low and comparatively level areas, where it has been practicable to do so, the contractors have loaded the soil directly into cars, throwing the track as the work progressed. On other portions of the work, where this method was impracticable, it was hauled in carts to dumping platforms and there dumped into cars. The soil has been deposited in the easterly portion of the dike.

The total number of carloads hauled during the year has been 190,558, amounting to 702,745 cubic yards; this, with the 665,058 carloads hauled during previous years, amounting to 2,181,647

cubic yards, makes a total of 855,616 carloads, amounting to 2,884,392 cubic yards.

Earth, consisting of either sand or gravel, has been deposited as needed to construct an embankment on the water side of the dike, with a thick gravel facing on the water slope. There have been 19,422 cubic yards of earth and 23,220 cubic yards of gravel used for this purpose during the year, which, added to the 45,250 cubic yards of earth and 1,136 cubic yards of gravel used in previous years, make totals at the end of the year of 64,672 and 24,356 cubic yards, respectively.

There have been 6,611 cubic yards of sand or gravel deposited as a covering over muck which was so deep that it was deemed inadvisable to excavate it; this amount, added to the 1,742 cubic yards used for a similar purpose in previous years, makes a total of 8,353 cubic yards.

The plant used by the contractors included 14 10 to 16 ton locomotives, 500 3½ cubic yard dump cars and 22.3 miles of 3-foot-gage track.

The total amount of work done under this contract has been : —

	To December 31, 1901.	In 1902.	Total.
Clearing and grubbing (acres),	623	296.6	919.6
Soil excavation (cubic yards),	2,206,653	702,745	2,909,398
Earth excavation (cubic yards),	47,120	26,033	73,153
Gravel excavation (cubic yards),	1,136	23,220	24,356

While the work at the North Dike is substantially completed, a considerable amount of work remains on Section 6, consisting of covering deep muck, grubbing stumps and roots and clearing up.

The maximum force employed was 707 men and 56 horses, for the week ending April 26.

Contract 183, Long & Little.

Excavating Soil from Section 7 of the Wachusett Reservoir, and building a Part of the Westerly Portion of the North Dike in Clinton and Boylston.

This contract was made on December 12, 1899, and called for the excavation of soil from about 313 acres of the Wachusett Reservoir site, known as Section 7, embracing the intervale north of the Cen-

tral Massachusetts Railroad, the steep slopes on the northerly side of the intervale between South Clinton and Sawyer's Mills, the intervale and slopes on both sides of Cunningham's Brook, and a portion of the Catholic Cemetery in Clinton. The contract also provided for the completion, with the exception of the slope paving, of the northeasterly 2,400 feet of the westerly portion of the North Dike, the completion of the main embankment of sand and gravel, and the partial construction of the soil embankment for an additional 1,700 feet.

The plant employed, exclusive of horses and carts, has been 4 12 to 15 ton locomotives, 100 2½ yard dump cars and 3.5 miles of 3-foot-gage track.

During the year the soil has been removed by a car plant, no material being transported to the dike entirely by carts. Only one dumping platform has been used. Carts have been used to a considerable extent to dump material excavated from the slopes along the sides of the track, to be subsequently loaded into cars. On the steep slopes south of Sandy Pond wooden chutes or troughs lined with sheet iron were used, the laborers shovelling the soil directly into the chutes, where it would slide to the track at the bottom of the slope.

During the year 40,775 carloads of soil have been removed, containing 116,029 cubic yards; during the previous years, 137,829 carloads, containing 382,130 cubic yards, — making a total at the end of 1902 of 178,604 carloads, containing 498,159 cubic yards of soil.

There have been 849 cubic yards of sand or gravel used to cover deep muck during the year, and 30,410 cubic yards in previous years, making a total at the end of 1902 of 31,259 cubic yards. The gravel used for facing the dike was excavated from a pit between Sandy Pond and the cemetery.

The total amount of work done under this contract has been : —

	To December 31, 1901.	In 1902.	Total.
Clearing and grubbing (acres), ...	136	42.81	178.81
Soil excavation (cubic yards), ...	479,943	116,029	595,972
Earth excavation (cubic yards), ...	30,574	849	31,423
Gravel excavation (cubic yards), ...	27,585	13,450	41,035

The value of the work done, as shown by the final estimate, was $220,003.15.

The maximum force employed was 227 men and 16 horses, for the week ending April 26.

The contractors completed the work on September 11, 1902, although the contract did not require its completion until July 1, 1903.

Contract 210, Newell & Snowling Construction Company.

Excavating Soil from Section 8 of the Wachusett Reservoir, and building a Part of the Westerly Portion of the North Dike in Clinton and Sterling.

On August 1, 1901, a contract was made with the Newell & Snowling Construction Company for removing soil from Section 8 to the westerly portion of the North Dike. This contract called for the removal of a sufficient amount of soil to complete the westerly portion of the dike, estimated at 935,000 cubic yards. The area from which the soil was to be removed embraced about 550 acres, of which 410 acres required clearing and grubbing, and included all the territory north of the river below Sawyer's Mills, not included in previous contracts, and a considerable tract at and above Sawyer's Mills north of the Central Massachusetts Railroad. The contract also provided for the excavation of about 77,000 cubic yards of earth and gravel for the completion of the embankment along the water slope of the dike, and for covering deep muck which it was not considered desirable to remove.

The material nearest the dike is hauled to the dike in carts, and that from greater distances in cars. During the early part of the season the material removed in cars was taken from the intervale and steep slopes above Sawyer's Mills, that on the intervale being loaded directly into cars, and that from the slopes in some cases being shovelled down the slopes and loaded into cars, and in other cases hauled in carts to dumping platforms. The cars were transported by a locomotive to the foot of an incline having a grade of 10 per cent. near the West Boylston Road, above Sawyer's Mills, thence hauled up the incline by the use of a stationary engine, and from the top of the incline transported to the dike by locomotives. During the latter part of the season the car plant was employed in a similar manner on the high ground between Sawyer's Mills and the North Dike, the incline and stationary engine being temporarily abandoned.

By the operation of the railway and car plant, 92,822 carloads, containing 321,504 cubic yards of soil, were transported to the dike; this, added to the 15,830 carloads, containing 51,747 cubic yards, transported in the previous year, makes a total of 108,652 carloads, containing 373,251 cubic yards.

The plant consists of 4 12-ton locomotives, 100 3 cubic yard dump cars, 1 70 horse-power hoisting engine and 4.9 miles of 3-foot-gage track.

The total amount of work done under this contract has been: —

	To December 31, 1901.	In 1902.	Total.
Clearing and grubbing (acres),	54	168.2	222.2
Soil excavation (cubic yards),	100,553	341,652	442,205
Earth excavation for embankment at dike (cubic yards),	10,600	2,772	13,372
Earth excavation for covering muck (cubic yards),	0	36,991	36,991

The amount of work done at the end of the year was considerably in excess of the requirements of the contract.

The maximum force employed was 303 men and 48 horses for the week ending May 3.

Contract 229, Meskill Brothers & Leahy.

Excavating Soil from Wachusett Reservoir, and building a Part of Worcester Street in West Boylston.

On April 4, 1902, a contract was made with Meskill Brothers & Leahy for the construction of portions of the relocation of the highway in West Boylston, from Worcester Street on the southerly side of the reservoir to the junction of Sterling and Lancaster streets on the northerly side of the reservoir, not included within the limits of the reservoir.

Work under this contract was commenced April 14, 1902. The maximum force employed was 47 men and 20 horses, for the week ending May 17; and the contractors completed their work on August 25, 1902, except a small amount of grading and drains under the Worcester, Nashua & Portland Division of the Boston & Maine Railroad. This work could not be done, because the railroad company, which was building the overgrade bridge at this place, had not completed its work and removed the piling from the road-bed.

The principal quantities of work performed were as follows: —

Earth excavation (cubic yards),	26,228
Dry paving (cubic yards),	60
Masonry (cubic yards),	166
5-inch side drains (linear feet),	1,936
Cast-iron and sewer pipe culverts, 12 to 15 inches in diameter (linear feet),	214
Rock excavation (cubic yards),	274

The amount of the final estimate was $9,263.95.

Of the earth excavation given above, 5,490 cubic yards was soil removed from the Wachusett Reservoir, a large portion of which was used for dressing the slopes of embankments.

Contract 246, Nawn & Brock.

Section 3 of the Relocation of the Central Massachusetts Railroad in Clinton.

On May 6, 1902, a contract was made with Nawn & Brock for the construction of the portion of the relocation of the Central Massachusetts Railroad extending from a point approximately 700 feet east of the easterly end of the North Dike to junctions with the Worcester, Nashua & Portland Division at two points; the main line running westerly and joining the Worcester, Nashua & Portland Division about half a mile southwest of the South Meadow Road in Clinton, the other line (known as the Y) turning easterly toward Clinton and joining the same division near the southwesterly shore of Coachlace Pond. The contract also covered the construction or reconstruction of the Clinton-West Boylston Road, from a point a short distance west of South Main Street to a point a short distance west of the South Meadow Road, the construction of the relocation of the South Meadow Road, and the placing of screened gravel or broken stone on the water slope of the dike and of the railroad embankment east of the dike, to serve as a foundation for riprap. As a part of the construction of the railroad, the contractors were required to build stone and concrete masonry abutments for a steel bridge over the Clinton-West Boylston Road. As far as practicable, the soil excavated from the reservoir under their other contract was to be used in making the railroad and road embankments, except where other material was available from the railroad and road excavations. The extreme westerly portion of the line was so situated that it was better to borrow earth from the vicinity to make the embankments. The gravel needed for surfacing the roads,

ballasting the railroad and protecting the water slopes of the railroad embankment was also obtained from borrow pits.

The principal quantities of work performed under the contract are approximately as follows: —

Earth excavation (cubic yards),	22,100
Rock excavation (cubic yards),	310
Soil taken from Section 6, measured in embankment (cubic yards),	53,100
Gravel for the water slope of the embankment east of the dike, for ballast on the railroad and for surfacing the roads (cubic yards),	7,500
Screened gravel in place (cubic yards),	4,934
Concrete and stone masonry (cubic yards),	434
Cast-iron pipe in culverts (tons of 2,000 pounds),	20

The work on the roads, on the Y and on all of the main line of the railroad, except the extreme westerly portion, is substantially completed.

The maximum force employed was 116 men and 16 horses, for the week ending October 25.

Contract 247, George M. Atkins & Co.

Section 4 of the Relocation of the Central Massachusetts Railroad in West Boylston.

On June 5, 1902, a contract was made with George M. Atkins & Co. for the work connected with the relocation of the railroads in and near the village of Oakdale, embracing a change in the location of the Worcester, Nashua & Portland Division, connecting curves between the two railroads, and slope paving along the railroad embankments where they will be flooded.

The material for the embankments, when not obtained from the railroad excavations, was to be obtained by taking the soil from that portion of the Wachusett Reservoir lying between the two railroads on the north and west and the Quinepoxet and Stillwater rivers on the south and east, also the soil in and around the Oakdale mill-pond north of the Central Massachusetts Railroad, and on both sides of the Worcester, Nashua & Portland Division.

The preliminary estimates called for 130,000 cubic yards of earth excavation, 5,700 cubic yards of riprap and slope paving, 25 cubic yards of masonry and 325 linear feet of cast-iron and sewer pipe drains and culverts from 6 to 18 inches in diameter.

The contractor commenced work on June 11, 1902, and has accomplished all that can be economically done until changes are made in the location of the railroad tracks.

The total amount of work done has been : —

Earth excavation (cubic yards),	100,654
Riprap and slope paving (cubic yards),	3,217
Masonry (cubic yards),	5
Cast-iron pipe culverts (linear feet),	70

The maximum force employed was 129 men and 53 horses, for the week ending September 20.

Contract 257, Bruno, Salomone & Petitti.

Section 10 of the Wachusett Reservoir in Boylston and West Boylston.

On December 27, 1902, a contract was made with Bruno, Salomone & Petitti for the construction of what is known as Section 10 of the Wachusett Reservoir. This contract calls for clearing, grubbing and excavating soil from some 700 acres toward the upper end of the Wachusett Reservoir. It includes substantially all of the soil-stripping westerly from that provided for under the contracts of Nawn & Brock and the Newell & Snowling Construction Company and southerly from that provided for under the contract of George M. Atkins & Co. In addition the contract provides for excavating earth and gravel from shallow portions of the reservoir at Oakdale, for enlarging a portion of the channel of the Quinepoxet River west of the Worcester, Nashua & Portland Division, building a concrete dam across the Quinepoxet River at the upper end of this channel, excavating gravel to obtain material for protecting the slopes of embankments, excavating — chiefly in rock, to a maximum depth of about 50 feet — a new channel for the Nashua River at the highway crossing the reservoir at West Boylston, and paving the slopes of embankments and the bottom and slopes of the new channel of the Quinepoxet River.

The excavated soil and other materials are to be deposited to fill a portion of the reservoir at Oakdale which would otherwise be very shallow, to build the embankment for a highway across the reservoir at West Boylston, and for embankments of other highways across and near the reservoir at Oakdale.

The preliminary estimate calls for clearing and grubbing 100 acres; excavating 970,000 cubic yards of soil, 135,000 cubic yards of earth and 15,000 cubic yards of rock; laying 23,500 cubic yards of paving, and building 1,200 cubic yards of concrete masonry.

As the contract was not made until a few days before the end of the year, no work was done under it during the year.

Improving the Wachusett Watershed.

The following work has been done at the expense of the Board on the Wachusett watershed, partly by a day-labor force and partly by the property owners above the flow line, in improving the sanitary conditions near the mills and dwelling houses: —

At the Dawson mill, in Holden, a cesspool has been constructed and drains laid from the closets in the mill to the cesspool, and a new privy with a cemented vault has been constructed. At Stewart's and Buck Brothers' mills, in East Princeton, and at the residence of Ellen H. Fairbanks, in Holden, similar privies have been constructed. An 18-inch sewer pipe drain 182 feet long has been laid to take the surface water around the cesspool on the land of Andrew J. Scarlett, in West Boylston, into the brook below.

The maximum day-labor force employed was 10 men and 4 horses, for the week ending October 11.

Land Surveys.

Surveys and plans for the use of the Attorney-General in land suits have been made of the Michael O'Malley property in Clinton, John F. O'Brien property in Boylston, and of the Glenn Woolen Mills, James Dorr proprietor, in Holden. A plan of the George H. Holmes property in West Boylston was made for the Conveyancing Department. Surveys and taking plans of the George R. Reed and Mary S. Mason properties in West Boylston have been made. Ten real estate plans have been revised.

Real Estate, Care and Disposal.

Rents have been collected on houses in the possession of the Board. Minor repairs have been made on houses to be maintained, and a considerable quantity of land products have been sold. A fire guard 40 feet wide along the margins of the land purchased by the Board has been extended by clearing trees and bushes from an additional length of 1.49 miles, making the total length of the fire guard at the end of the year 14.98 miles; of this length 4.59 miles have been planted with grass seed during the year. Interior cart roads 15 feet wide have been cleared for 6.02 miles, and the brush has been mowed on the fire guards and cart roads previously cleared. A furrow has been plowed where land purchased by the Board is adjacent to railroads. About 20.52 miles of interior cart roads have

been sufficiently graded, drained and otherwise improved to make passable roads, making a total of 21.52 miles of such roads. During periods of drought watchmen have patrolled the land to guard against fires. The brush along public roads opposite land purchased by the Board has been cut and removed. An area of something over 175 acres, mostly pasture land, was planted during the spring with white pine and sugar maple seedlings, set in rows 5 feet apart each way; 74,200 white pine seedlings and 236,500 sugar maple seedlings were used; the white pines were taken from the nurseries, and the sugar maple seedlings were obtained from Tolland, Mass. A furrow has been plowed around this planted area, 16,178 feet in length, for protection against fires. The necessary clearing has been done on 42 acres, preparatory to tree planting the coming spring. The forest tree nursery on the south side of the reservoir has been enlarged by 0.68 of an acre. In the two nurseries, 372,130 one, two and three year old white pine seedlings, and 26,000 two year old sugar maple, oak and chestnut seedlings have been transplanted from seed beds to nursery rows; 76,750 two year old white pine seedlings taken up in the nurseries, and 230,000 maple seedlings from Tolland, Mass., have been heeled in in the nursery on the south side of the reservoir ready for the spring planting. Three rows of white pine seedlings, 6 feet apart each way, were planted along the shore of the southerly side of the reservoir for a distance of 12.65 miles. There have been 570 feet of division fences built and 11 stone monuments set on land lines. In West Boylston, 35 dwellings, 11 barns, 5 shops, 4 stores, 1 mill and 3 halls, making a total of 59 buildings, have been torn down or removed during the year, making a total of 209 at the end of the year. The dam formerly belonging to the West Boylston Manufacturing Company in the Quinepoxet River has been removed. A large portion of the two dams formerly belonging to the L. M. Harris Manufacturing Company, having been wrecked by the spring floods, were removed.

Sanitary Inspection.

The camps for laborers employed upon the construction of the Wachusett Reservoir have by constant vigilance been kept fairly clean. Many houses in West Boylston that were located close to the streams and were a menace to the purity of the water have been removed. Further information with regard to the sanitary inspection of the Wachusett watershed will be found under the head of Maintenance.

Removal of Bodies from St. John's Catholic Cemetery.

As the work of excavating progressed at the cemetery, 30 bodies were found, and upon notification they were removed by the representatives of the Cemetery Association. This makes a total of 3,902 bodies removed from the cemetery. The last body was found during the week ending April 19, and after continuing the excavation until May 2 this work was discontinued, as it seemed evident that all the bodies had been removed.

Engineering.

In addition to the engineering work already enumerated and that necessarily connected with the contract and day-labor work in progress, the engineering force of the Reservoir Department has performed the following work: —

Several plans and sketches have been made for the new cemetery to receive the bodies to be removed from the small Beaman cemetery; levels of the ground at the Wachusett Reservoir, taken after the completion of the excavation, have been entered on record sheets; and contour lines have been drawn, covering an area of some 600 acres, making a total area covered by these final records at the end of the year of 1,520 acres. Measurements have been made from these sheets, covering an area of 470 acres, for the purpose of determining the capacity of the reservoir, making a total area covered at the end of the year of 1,000 acres. Gage readings have been taken daily in Coachlace and Sandy ponds, and at the Prospect Street bridge over the Nashua River in West Boylston during floods. Gage readings on the storage reservoirs in the Wachusett watershed have been taken on the 1st and 15th of each month, and the storage at each date has been computed. The water areas on the Wachusett watershed (ponds, rivers and brooks) have been computed. Lists have been made to determine the amount to be paid by the Board for taxes or in lieu of taxes to the towns of Clinton, Boylston and West Boylston. Surveys and investigations have been made to aid in determining the extent of the damage to the Bigelow Carpet Company by the diversion of water from its mill, and much other minor engineering work has been attended to.

DAM AND AQUEDUCT DEPARTMENT.

T. F. RICHARDSON, *Department Engineer.*

The principal work in this department has been the construction of the Wachusett Dam, the location and the construction of a portion of the relocated line of the Central Massachusetts Railroad and the placing of riprap on the North Dike. The department has also had charge of the operation of the Wachusett Aqueduct and the Clinton sewerage system.

The organization of the force has continued practically the same as during the previous year. Alexander E. Kastl, division engineer, continued in charge of the surveys for the relocation of the railroad until May 10, when he resigned to accept the position of chief engineer of the Denver Union Water Company; and Moses J. Look was transferred from the Reservoir Department to take charge of the construction of the railroad, the location having been finished under Mr. Kastl. Chester W. Smith, assistant engineer, continued in charge of the work of the Wachusett Dam. The work in the drafting office is in charge of Allen E. Shannan. Elliot R. B. Allardice has continued in charge of the river and aqueduct gagings, and has direct supervision of the maintenance of the Clinton sewerage plant.

The engineering force at the beginning of the year numbered 21, and reached a maximum in August of 28. There were also 6 masonry inspectors.

The main office of this department is in Clinton, and a branch office has been maintained near the Wachusett Dam.

WACHUSETT DAM.

The design of the Wachusett Dam, and the contract for its construction, which was made with the McArthur Brothers Company on October 1, 1900, were described in the annual report of January 1, 1901. The plant provided for the work and the methods of carrying on the work both at the quarry and at the dam were fully described in the last annual report, and there has been no material change in the plant or in the methods. The work has been carried on throughout the year, although work upon the masonry, which was suspended on December 3, 1901, on account of the cold weather, was not resumed until March 24, 1902. On the whole,

good progress has been made upon the work, although the progress does not equal the requirements of the contract. This has been due in part to the industrial conditions during the past year, which have made the work much more difficult of accomplishment, and have also added materially to the cost of the work to the contractor. As a result of the coal strike, it has been difficult to obtain a sufficient supply of coal to operate the air compressors, and at times there has been less than twenty-four hours' supply of coal on hand; but it has not been necessary at any time to stop the work on this account. It has also been difficult to obtain sufficient cement, especially Portland cement; and the construction of the masonry, particularly the concrete masonry, has been seriously delayed, in consequence. The shortage of cement has been due in part to the scarcity of coal, but still more to the unprecedented demand for cement for construction purposes all over the country. Other supplies have been obtained with difficulty, and there has been a scarcity of good foremen and other skilled labor.

Main Dam and Gate-chambers.

When the work upon the masonry was discontinued in 1901, its top was substantially at elevation 255, or about 19 feet below the bottom of the large flume, and the masonry was limited wholly to the length of dam between the large and small flumes. At the beginning of 1902, excavation was in progress for 90 feet westerly from the large flume; and when the construction of masonry was resumed, on March 24, this excavation had been finished, except that the cut-off trench, 20 feet wide, remained to be excavated in the rock. To excavate this cut-off trench a derrick was installed on the hillside, and the rock lifted out of the trench by the derrick was put into small cars on a short track and dumped on the westerly hillside above the dam. The rock at this place was a hard, brittle granite, somewhat seamy, especially near the surface. The excavation was carried to a sufficient depth to obtain rock nearly free from seams, the average depth of the excavation in the granite rock being about 14 feet and in the cut-off trench about 15 feet additional.

After the resumption of work on the masonry, the height of the portion of the dam between the flumes increased quite rapidly, and the filling on both the up-stream and the down-stream sides was carried on at the same time, so that on June 22 it was feasible to

WACHUSETT DAM — DOWN-STREAM SIDE, VIEW OF DAM AND SUBSTRUCTURE OF GATE-CHAMBER.

remove a portion of the large flume at the site of the dam and begin to extend the masonry. The flow of the river at this time was so small that it could be turned through the small flume into the aqueduct, and during the construction of this portion of the dam the flow at no time exceeded the capacity of the small flume, so that there was no trouble from any overflow.

The excavation for the foundation of the dam at the site of the flume was made before the flume was built, with the exception of the cut-off trench in the rock; this was excavated as expeditiously as possible, and the masonry was extended to the end of the excavation, about 90 feet west of the flume. As the masonry was built up, a portion, for a length of 40 feet at the crossing of the flume, was left lower than other portions, thereby making what is called a gap in the dam, through which water may overflow when the volume of water flowing in the river exceeds the capacity of the small flume. At the end of the season this gap was left at elevation 283, which is about 9 feet higher than the bottom of the flume. For about 20 feet at the down-stream side of the dam, at this place, the masonry was built only to the elevation of the bottom of the flume, so that the water in case of overflow would fall upon the masonry.

At the easterly end of the dam a night force was organized on May 8, to resume excavation from the trench between the easterly end of the masonry constructed during the previous year and the small flume, also to excavate for a foundation for the lower gate-chamber. Early in August this force began excavating the trench beyond the small flume; and this work was continued, largely by the night force, until the latter part of November, when the excavation, including the cut-off trench, was completed and ready for the masonry. The earth overlying the rock on this side of the valley had a depth of from 25 to 40 feet below the natural surface, though a portion had already been excavated in connection with the construction of the small flume. The material was a boulder clay or till, so compact and hard that it was found economical to loosen it by blasting.

The rock in the vicinity of the small flume is a schist, generally black and soft, but practically impervious to water. Much of the earth excavated was shovelled into large skips, which were conveyed by the cableways to derricks on or near the dam, which in turn deposited the clayey material against the up-stream face of the dam.

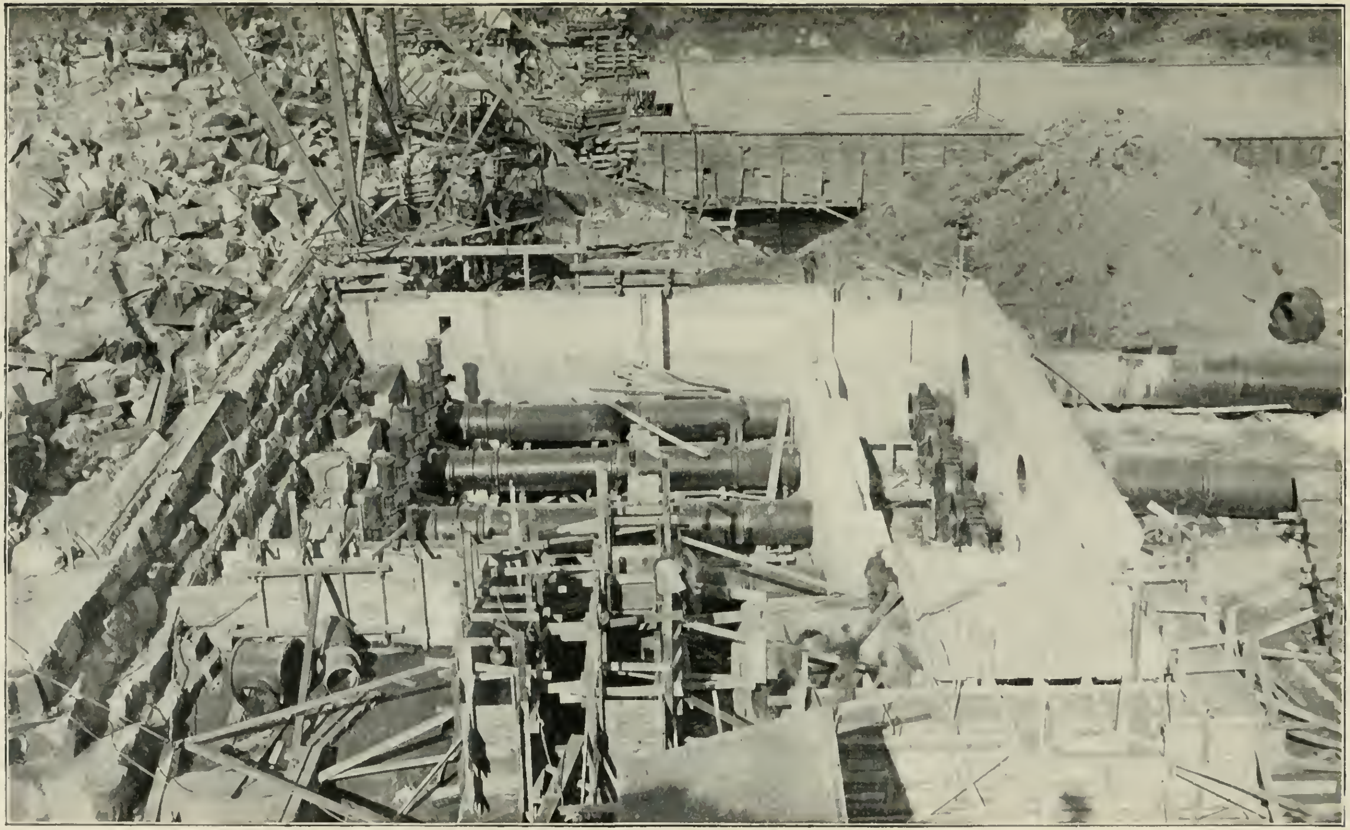
Some of the material was removed by wheelbarrows and carts, and used for filling around the lower gate-chamber and the conduits leading from the same. The average depth of the excavation in the portions of the schist rock which have been excavated this year was about 15 feet, and the cut-off trench, 20 feet in width, was excavated to an additional depth of about 16 feet. The rock was partly removed by the cableways and derricks, in the same manner as the clayey material, and dumped outside of it on the up-stream side of the dam, and partly removed by cableways to cars and dumped on the easterly hillside above the dam.

In excavating the cut-off trench on both sides of the valley, the method adopted last year, and described in the last annual report, of drilling lines of 3-inch holes 6 inches apart on centres on both sides of the trench, was followed.

As soon as the excavation for the dam had been extended as far as the small flume, the masonry was extended to the end of the excavation. This extension was sufficient to permit the construction of the upper and lower gate-chambers, and the laying of the four lines of 48-inch cast-iron pipes through the dam.

On May 18 the first concrete masonry was put in place in the substructure of the lower gate-chamber, which is built almost entirely of such masonry, and in all cases is founded upon the schist rock. In preparing the foundation, all earth and all loose or detached pieces of the rock were removed, but none of the more solid rock. As the foundation is, at the westerly side of the gate-chamber, about 15 feet below the bottom of the wells in the gate-chamber, only the walls were extended to the rock, and arches were built from wall to wall to support the concrete in the bottom of the wells, the space under the arches being filled with well-compacted earth. The foundation walls below the level of the arches have been built of natural cement concrete masonry, mixed in the proportion of 1 part by measure of cement, 2 parts of sand and 5 parts of screened gravel. All other portions of the gate-chamber have been built with Portland cement concrete, mixed generally in the proportion of 1 part by measure of cement, 2½ parts of sand and 4½ parts of screened gravel.

Beginning early in September, the 48-inch cast-iron pipes which pass through the dam from the upper to the lower gate-chamber were put in place. These were set in the first instance on brick



WACHUSETT DAM — SUBSTRUCTURE OF LOWER GATE-CHAMBER AND POWER HOUSE.

piers to hold them in place until the lead joints were calked, and subsequently brickwork was built under and around them to the height of the middle of the pipe. Brickwork was used instead of rubble for this portion of the work, with a view to obtaining a more perfect joint between the masonry and the pipe than could be obtained by the use of stone. The laying of the 48-inch pipes was followed by such other work as was necessary in order to provide for conveying the water from the upper part of the small flume through the permanent pipes to the aqueduct. This work consisted of placing the various valves and pipes in the upper and lower gate-chambers; extending the aqueduct to connect with the lower gate-chamber; building a permanent wall on one side and a coffer-dam on the other side of a channel 42 feet wide, connecting the upper part of the small flume with the upper gate-chamber; and placing a temporary wooden screen across this channel 6 feet above the upper gate-chamber, to prevent ice and other material from entering the pipes. When these works were substantially ready for use, the lower portion of the small flume was removed, and the extension of the masonry of the dam to a point 50 feet beyond the flume was begun. Water was first turned through the pipes on November 20. As it was already cold weather before the extension of the masonry was begun, only the up-stream part of the masonry has been built, and this will be raised only to such elevation as seems necessary in order to make this end of the dam secure against floods.

The masonry on the up-stream side of the dam, where it is to be covered with earth, has been built with squared stones having joints not exceeding 1 inch in width. Above the level of the earth both the up-stream and down-stream sides are faced with ashlar, built in 2-foot courses with ½-inch joints. On a considerable portion of the upper face of the dam 7 courses have been laid, and on the down-stream side 4 courses. All of the ashlar has been obtained from the quarry from which the rubble for the dam has been taken. The masonry of the up-stream face has reached the following elevations: —

Sta 3 + 04 to Sta. 3 + 99, easterly end to near upper gate-chamber,	293
Sta. 4 + 20 to Sta. 6 + 20, upper gate-chamber to gap through dam,	312
Sta. 6 + 50 to Sta. 6 + 90, gap in dam,	283
Sta. 7 + 15 to Sta. 7 + 80, gap to end of masonry,	307
Average elevation of up-stream face of dam,	304

In comparison with these elevations, it may be stated that the bed of the river at the site of the dam was at elevation 266, and the bottom of the pipes through the dam is at elevation 284.

Waste Conduits, Pool and Spillway.

The four 48-inch pipes passing through the dam and lower gate-chamber were extended by means of four pipes, each of which diverges so that its diameter increases to 8 feet in a length of 40 feet. These diverging pipes were made of cast-iron for a length of 5 feet, where they pass through the concrete, and for the remainder of the length are of riveted steel. At their larger ends these pipes connect with the waste conduits built of Portland cement concrete, which continue to increase in size until their area is equivalent to that of a circle 10 feet in diameter, and they continue of this size to the pool. A small portion of these conduits was built of natural cement, at a time when Portland cement could not be obtained; but where this cement was used, the thickness of the walls was increased.

The pool, which is constructed wholly of Portland cement concrete, was built to the extent that it is feasible to build it until water is prevented from flowing over the dam, but was also constructed with reference to conveying while unfinished such water as may be discharged through the 48-inch pipes.

Work has been continued on the spillway and apron a short distance below the pool; and the apron, which consists of ashlar paving on a rubble masonry foundation, has been completed. The curved retaining wall at the easterly end of the spillway has also been partially built, and some of the dry stone paving below the apron has been put in place.

The building of these structures was carried on from time to time during the year, and the last masonry was put in place November 30. The purpose in building these structures at this time was in part to furnish a place for disposing of the material to be excavated from time to time during the construction of the dam, but more particularly to furnish an opportunity for conveying water from the end of the 48-inch pipes to the river below the dam. At the end of the year only a short length of wooden flume remained to be constructed, between the pool and the spillway, in order to complete these works for conveying water.

Amount of Work done and of Materials used.

The following table gives the amount of work done to the end of 1901, the amount of work done during 1902, the total amount done to the end of 1902, and, for comparison, the total estimated amount required by the contract: —

	To December 31, 1901.	In 1902.	Total to December 31, 1902.	Total Estimated Amount.
Earth excavation (cubic yards), . . .	43,000	31,900	74,900	267,300
Rock excavation (cubic yards), . . .	24,370	12,020	36,390	100,000
Rubble stone masonry (cubic yards), . .	28,486	65,686	94,172	265,000
Ashlar masonry (cubic yards), . . .	65	684	749	10,300
Dimension stone masonry (cubic yards), .	-	58	58	2,900
Brick masonry (cubic yards), . . .	-	407	407	1,300
Concrete masonry (cubic yards), . . .	-	5,284	5,284	8,300
Iron and other metal work (tons), . .	-	582	582	1,000

The number of barrels of cement used in the work at the dam has been as follows: —

	To December 31, 1901.	In 1902.	Total to December 31, 1902.
Portland cement, ...	17,703	21,865	39,568
Natural cement, ...	8,892	52,896	61,788

All of the natural cement has been of the Union brand, and 31,839 barrels of the Portland cement have been of the Giant brand, — both cements being manufactured by the American Cement Company of Egypt, Pa. The remaining 7,729 barrels of Portland cement, which were either furnished by the American Cement Company or otherwise obtained when a sufficient quantity of the Giant cement could not be supplied, have been of the following brands: 4,260 barrels of Ironclad, 2,894 barrels of Atlas, 225 barrels of Alsen, 200 barrels of Helderberg and 150 barrels of Alpha.

The amount of cement used in the dam per cubic yard of each class of rubble masonry was as follows: —

COMPOSITION OF MORTAR BY MEASURE.	Barrels of Cement per Cubic Yard.	Cubic Yards Built.
1 part natural cement to 1 part sand,	1.43	184
1 part natural cement to 2 parts sand,	1.00	59,451
1 part Portland cement to 2 parts sand,	1.08	17,444
1 part Portland cement to 2½ parts sand,	0.86	8,926
1 part Portland cement to 3 parts sand,	0.75	6,466

The amount of cement used per cubic yard of each class of concrete masonry was as follows: —

COMPOSITION OF CONCRETE BY MEASURE.	Barrels of Cement per Cubic Yard.	Cubic Yards Built.
1 part natural cement, 2 parts sand and 5 parts stone,	1.36	726
1 part Portland cement, 2½ parts sand and 4½ parts stone,	1.43	4,241
1 part Portland cement, 3 parts sand and 6 parts stone,	1.06	317

Miscellaneous Notes.

The work of building the rubble masonry, as already stated, was resumed on March 24, and, although the weather was unusually favorable for the season of the year, the masonry was laid in Portland cement mortar mixed in the proportion of 3 parts of sand to 1 part of cement until April 12. Toward the latter part of the season masonry which was likely to be exposed subsequently to the action of frost was laid in Portland cement mortar of the kind above stated, and after November 15 all masonry was so laid. After November 28 the sand and mortar were heated and salt was added to the mortar, 4 pounds being used to each barrel of cement. For heating the sand, a bin 16½ feet long, 15½ feet wide and 10 feet deep was provided with about 20 coils of 2-inch pipe, which pass around the bin on the inside 2 feet from the sides of the bin. The sand is dumped into the top of this bin and drawn from the bottom, remaining in long enough to become warm. The water used for mixing the mortar is heated by steam, and the proper amount of salt for each batch of mortar is dissolved in the water. Steam was provided to thaw ice from the stones and masonry.

The work of laying masonry was not started on mornings when the temperature was lower than 18° above zero, and not with this temperature unless the day was clear and a higher temperature was

expected. After each day's work the masonry built was covered with canvas. Between April 12 and November 15 most of the masonry was laid in natural cement mortar, mixed in the proportion of 2 parts of sand to 1 part of cement; but Portland cement mortar, mixed in the proportion of 2 parts of sand to 1 part of cement, was used as heretofore for the masonry in the cut-off trench, for the first courses of masonry above the ledge rock, and was also used in the upper gate-chamber around the brick wells.

The largest amount of rubble masonry laid in the dam during any week was during the week ending August 30, when 9 derricks were in operation, and 2,751 cubic yards were laid.

The building of the concrete masonry was done almost entirely at night, when one of the cableways could be spared to convey the concrete, which was mixed in the cubical mixer on the side hill, to the bottom of the valley.

All of the permanent pipes, specials and valves which have been built into the dam have been made very thick, to insure their permanence. The 48-inch pipes through the dam have a 2-inch shell, and weigh more than 1,000 pounds per foot, including the bells. The 48-inch valves in the upper gate-chamber weigh about 9 tons each, without the stems. The 48-inch valves with hydraulic cylinders in the lower gate-chamber are not as heavily built as the others, because they will be accessible for repairs or replacing in the future; but, including the cylinders, they weigh more than 11 tons each. These were placed by two cableways, which were used together for this purpose.

The progress of the work has rendered a part of the temporary works unnecessary. Mention has already been made of the removal of the large and small flumes where they crossed the site of the dam. As soon as the dam had been built to a sufficient height above the bottom of the large flume to hold a body of water between it and the temporary dam, there was no further need for the greater portion of the flume between the two dams, and it was removed by the contractor, leaving only about 80 feet, including the headworks, at the temporary dam. Later in the season the portion of the large flume below the dam became useless, and, as it might cause trouble at points below if it should be carried away by a freshet, it was removed by employés of the Board, though the work was not wholly completed at the end of the year.

The lower protective dam was entirely removed, in order to permit the building of the masonry of the pool.

The height of the water in the river is still regulated at the temporary dam. The flow of the river has been so small that it has been feasible to divert it through the aqueduct nearly all of the time; and water overflowed at the gap in the dam only on October 28 and 29, on November 19 and 20, when the flow into the aqueduct was stopped at the time of the removal of the small flume, and from December 17 to 31.

Relocation of the Central Massachusetts Railroad.

Reference to the agreement made between the Board and the Boston & Maine Railroad for the relocation of the Central Massachusetts Railroad around the reservoir, and a description of the new line and its subdivision into sections, have already been given on page 91. The following statement relates to the work done upon this railroad under the direction of the Dam and Aqueduct Department.

At the beginning of the year, surveys were in progress for the route, which has since been adopted, between West Berlin and the junction with the Worcester, Nashua & Portland Division. These surveys were continued until the latter part of March, when the final location was determined.

From West Berlin to a point near Boylston Street in Clinton it was necessary to take land for the railroad, and surveys and plans were made for this purpose. Estimates were also made of the quantities of material and of the cost of the work.

Detailed plans were made of the site of the viaduct and various bridges and culverts, as a basis for the design of these structures. An estimate was also made of the cost of building a track for the Central Massachusetts Railroad, parallel with the tracks of the Worcester, Nashua & Portland Division, from the point of junction to a point near Oakdale, and of the cost of abolishing the grade crossings of highways between the same points.

To determine the position of the surface of the rock along the located line, 17 wash drill borings, having an aggregate depth of 334 feet, and 97 rod soundings, having an aggregate depth of 584 feet, were made.

Contracts, Central Massachusetts Railroad.

Section 1, Crary Construction Company.

Date of contract, May 26, 1902; amount of contract, $36,767.50; length of section, 7,740 feet.

This section is partly in Berlin and partly in Clinton, and extends from the end of the iron bridge at West Berlin to near the middle of a swamp, a short distance easterly from the tunnel. Much of the excavation is through ledge, and the earth is a clayey gravel with boulders. All of the material from the excavations is being used to make the embankments, requiring, in some cases, a haul of nearly half a mile. There is one undergrade highway crossing with a span of 30 feet, five culverts and two cattle passes on this section. The bridge abutments are made of granite ashlar backed with concrete. By the terms of the contract all of the work should have been completed on December 1. At the end of the year all masonry work had been completed, but there remained considerable earth and rock work to be done, though not more than could be finished in time for laying the tracks as soon as the frost is out of the ground in the spring. The excavation was begun on June 11.

The average force employed was 113 men and 17 horses. The maximum force was 160 men and 21 horses, for the week ending September 20, 1901.

Section 2, McArthur Brothers Company.

Date of contract, April 18, 1902; amount of contract, $236,621; length of section 5,860 feet.

As has already been stated, a contract for this section of the railroad was made with the McArthur Brothers Company, contractors for the Wachusett Dam. This section is located for a considerable distance within the territory where the contractor for the dam has work to do, and the construction of the railroad necessarily interferes with the work to be done under the contract for the dam. The permanent location of the railroad runs across the tracks upon which the westerly towers supporting the cableways rest, and, if built at the present time, would interfere seriously with the use of the cableways. To obviate this trouble as far as practicable, a temporary location with sharp curves was adopted for a distance of 1,317 feet, so as to pass as far as possible around the cableway tracks, decreasing the dis-

tance that the cableway towers can be moved in a northerly direction only about 80 feet. Both the permanent and temporary locations cross the waste channel through which water flowing over the waste weir is to run. And in other respects there would have been considerable interference had the railroad work been given to another contractor. There was also an advantage in having both the railroad and the dam constructed by the same contractor, as it was possible in making the contract to provide that portions of the railway embankments should be made with material excavated at the dam without extra charge.

A much more important consideration, however, was the speed with which the work could be done. In order to excavate the tunnel and heavy rock cuts with reasonable speed and economy, it would have been necessary for another contractor to install a large plant to furnish power for the work, and the time required for getting heavy machinery would have resulted in serious delay. The contractor for the dam, on the other hand, had a very large air-compressing plant, which had a diminishing quantity of work to do, and consequently sufficient surplus power for the work upon the railroad. The pipes conveying the air from this power plant lead to the dam on both sides of the river, and it was an easy matter to extend the power to all portions of the new work. The contractor's organization was such that he began excavating at the deep rock cut at the westerly end of the section on April 18, the day the contract was signed, and also began at once to extend the compressed air mains to this rock cut and to both ends of the tunnel. On April 29 the work of excavating the approaches at both ends of the tunnel was begun. Tunnel excavation began at the west portal on May 31 and at the east portal on July 25.

The tunnel, which is about 1,080 feet long, is 22 feet high and 16 feet wide inside of the lining of concrete masonry. The easterly 790 feet of the tunnel are through a hard, close-grained granite, comparatively free from seams; and it is not the intention to line this part of the tunnel with masonry except for a short distance at the portal, where the frost will affect the rock. The excavation, however, is being made sufficiently large for the lining in places where it is not the intention to line it. For 200 feet the surface of the rock is slightly below the top of the tunnel, so that the top is in earth, and for the remaining 90 feet it is only a short distance above

the top of the tunnel, so that it will be necessary to line the whole 290 feet with masonry. For a total distance of 228 feet it has been necessary to support the top of the tunnel with heavy timbers during construction. The lining masonry will be carried a short distance outside of the tunnel, so that the length from portal to portal of the finished tunnel will be 1,110 feet.

The headings, which comprise the upper third of the tunnel, were excavated for their whole length before any bench was started at the easterly end, and before much of the bench had been excavated at the westerly end. They met during the week ending November 29. The average progress per week at the easterly end, where there was no timber, was nearly 60 feet, while through the timbered heading at the westerly end the progress was about 16 feet per week. The excavation to grade was started outside the tunnel at the westerly end during the week ending August 30, and at the end of the year this excavation had been carried into the tunnel, so that the tunnel was fully excavated for a distance of about 220 feet. At the easterly end of the tunnel at the end of the year the rock cut had not been completed to grade for nearly 200 feet from the end of the tunnel, but a derrick had been set up for the purpose of starting upon the excavation of the bench, or lower part of the tunnel, without waiting for the completion of the rock cut. No bench, however, had been excavated at the end of the year.

The material excavated from the easterly approach and from the easterly portion of the tunnel was used for making the high embankment in the low land at the easterly end of the section; the material excavated from the westerly end of the tunnel was deposited where it would fill a depression on the hillside a short distance below the dam.

The tunnel portals are to be finished with head walls of granite backed with concrete masonry, and some of the stones for this work have been cut, but none of them have been put in place, nor has any of the concrete masonry lining of the tunnel been built.

Adjoining the tunnel on the west is the site of the steel viaduct across the valley of the river, and the masonry, consisting of 2 abutments and 32 pedestals, is included in the contract for Section 2. All of this masonry is composed of coursed granite, with a backing or core and foundation of Portland cement concrete. One of the abutments and 6 of the pedestals are founded on schist

ledge rock, 4 pedestals on boulder clay, 4 on sand, and 1 abutment and 18 pedestals on gravel. The 14 pedestals in the bottom of the valley, some of which had to be built to a height of 25 feet in order to have their tops above the level of the restored mill-pond of the Lancaster Mills, are 7 feet square under the cap stones, which are 4 feet 6 inches square and 20 inches thick; while the remaining 18 pedestals are 6 feet square under cap stones, usually 4 feet square and 20 inches thick. The batters on all of the pedestals are 1½ inches per foot. The stone for this masonry was taken from the quarry which supplies the stone for the dam, except for 8 pedestals in the bottom of the valley, the stones for which were obtained from the quarry of H. E. Fletcher & Co., West Chelmsford, Mass. Work was commenced on the Boylston Street abutment on June 4, and at the end of the year all of the masonry had been finished except 4 pedestals in the bottom of the valley. The concrete masonry foundations for these pedestals were in place, and the stone had been delivered but not set. A considerable amount of stone is still to be deposited in the bottom of the valley, to protect the pedestals from erosion.

On the westerly side of the river the principal work required by the contract is the excavation of the long and deep rock cut through the side of the hill. By the requirements of the contract, the rock taken from this cut was to be separated, in accordance with its size, into two classes, and deposited on the outer slope of the North Dike as riprap; the smaller pieces being used in the inner portion of the riprap, and the larger pieces, which generally contain 1½ cubic feet or more, on the outside. In order to facilitate the progress of this work, a second opening was provided nearly in the middle of the cut by making a side entrance at a place where the depth was comparatively small.

The excavated rock has been loaded into "skips" having a capacity of about 1½ cubic yards of solid rock, and these were placed by means of derricks on flat cars which were hauled by mules to the North Dike, where the "skips" were again hoisted by a travelling derrick, swung around to the proper place and dumped.

The protection on the face of the dike consists, first, of a thick layer of unscreened coarse gravel; second, a layer of broken stone or screened gravel about 1 foot in thickness; and outside of these a layer of riprap, which is thicker at the top than at the bottom, and which has a horizontal thickness of 18 feet at elevation 391, which

is 4 feet below full-reservoir level. The outer 6 feet are composed mostly of stones which contain 1½ cubic feet or more, while the remainder is composed of the smaller stones. The top of the riprap is at elevation 400, which is 5 feet above full-reservoir level; and its bottom rests on a gravel berm at elevation 382, or on the natural surface of the ground when higher than this level. It has not been thought necessary to place riprap below the berm, except, to a limited extent, opposite Sandy Pond; because, if the water in the reservoir is lowered nearly to the level of the berm, it will be so shallow in the vicinity of the dike that there can be no waves of any considerable magnitude.

In addition to the riprap on the dike, the portion of the railroad embankment which will be exposed to the waves in the reservoir was also protected with riprap in the same general manner as the North Dike, although not quite as thoroughly. At the end of the season the riprap had been completed on the railroad embankment and for a distance of 1,320 feet along the dike. The distance to which it was necessary to haul the riprap increased as the work progressed, and some of it was hauled 3,300 feet at the end of the year.

The following table gives the total quantity of work done to the end of the year, and the total estimated amount of work included in the contract: —

	Work done to December 31, 1902.	Total Estimated Amount of Work.
Earth excavation (cubic yards),	18,500	30,900
Rock excavation (cubic yards),	26,100	45,300
Tunnel excavation (cubic yards),	7,800	18,300
Concrete masonry not in tunnel (cubic yards),	1,920	2,460
Concrete masonry in tunnel (cubic yards),	0	1,800
Dimension stone masonry (cubic yards),	490	870

While a large amount of work has been done since April 18, the date of the contract, the progress of the work is considerably behind the requirements of the contract, and it will require very energetic work to complete the contract within the required time.

The average force employed by the contractor was 166 men and 18 horses; and the maximum force was 223 men and 27 horses, for the week ending August 23.

Steel Viaduct and Bridges, American Bridge Company of New York.

Date of contract, July 23, 1902; amount of contract, $91,450.

This contract includes the steel viaduct over Boylston Street and the Nashua River valley in Clinton, the bridge over the highway in Berlin on Section 1 of the railroad, and the bridge over the West Boylston Road in Clinton on Section 3 of the railroad. The viaduct, as already stated, is to have a length of 917 feet and a height above the lowest part of the valley of 133 feet. The bridge in Berlin has a span of 30 feet, and the bridge in Clinton, which crosses the highway at a considerable angle, has a span of 43 feet. Plate-girder construction will be used throughout. At the viaduct the spans between towers are 72 feet, and at the towers 38 feet. The span from the last tower to the abutment at the westerly end is 53 feet, and at the easterly end 60 feet. It is provided in the contract that all three bridges shall be erected on or before March 1, 1903. At the end of the year one of the small bridges was completed but not erected, nearly all of the remaining material had been rolled, and the shop work upon the viaduct had been begun.

Mortar Experiments.

Mention was made in the last annual report of the extended series of experiments to determine the relative strength of mortars used immediately after wetting and mixing, and when used at different intervals up to two hours after they are first wet and mixed. These experiments were made entirely with Union natural and Giant Portland cements, which were the only brands used at that time in the dam. During the past year, when several brands of Portland cement have been used in the construction of the dam, this series of experiments has been extended to include three of the brands of Portland cement used in the dam, namely, Atlas and Ironclad, which are American cements, and Alsen, which is a German cement, and, in addition, an English Portland cement and two brands of American natural cement. The experiments were made with different grades of sand and with mortar which was worked continuously until put into the molds, also with mortar which was not worked after being first mixed until immediately before being put into the molds.

The time required for the briquettes of neat cement to set, so that

they would bear the light and heavy Gilmore needles, averaged for the natural cements 33 and 83 minutes, and for the Portland cements 89 and 330 minutes, respectively. The briquettes were broken at the end of 7 days, 28 days, 3 months and 6 months after mixing. The results were generally in accordance with those obtained with the Union and Giant brands last year, as given in the last annual report.

Taking first the results with the two brands of natural cement, it was found that breaking tests at the end of 7 days indicated considerable loss of strength when the mortar was put into the molds 1½ and 2 hours after being first wet, instead of being put in immediately after mixing; but the breaking tests at the end of longer periods showed that delay in putting the mortar into the molds increased its strength. Briquettes broken at the end of 6 months showed an increase of 40 per cent. in strength, as the result of a delay of 1½ or 2 hours in filling the molds.

The results with the four brands of Portland cement showed that, whether the briquettes were broken at the end of 7 days or at longer periods, there was no loss of strength because of delay in filling the molds, even when the delay was as much as 2 hours, and the mortar after being first mixed was not again worked until immediately before filling the molds, and that there was a slight gain in strength when the mortar was mixed continuously.

In making these experiments 2,496 briquettes were made and broken.

In addition to the above-described experiments, others were made in January and December, to determine the effect upon the strength of the Portland cement mortar of the addition of salt in cold weather, and of the heating of the materials of which the mortar was composed; also, to what extent the strength of such mortar was affected by freezing, when mixed with both fresh and salt water. The mortar used in the experiments was composed of 1 part by measure of cement to 3 parts of sand. Salt was added to the mortar in the proportion of 4 pounds, 8 pounds and 16 pounds per barrel of cement. Briquettes were made to be broken 7 days, 28 days, 3 months, 6 months and 1 year after mixing. Only a portion of the briquettes have been broken up to the present time. The experiments indicated that the addition of salt to and the heating of the ingredients of the mortar have but little if any effect upon the strength of the

mortar. The briquettes which were frozen, when broken at the end of 7 days, had less strength than the briquettes not frozen; but at the end of 28 days they had more nearly the same strength, indicating that, while the mortar is slower setting, it may not be permanently injured by freezing. There were 970 briquettes made for these experiments.

Improvement of Channel of Nashua River below the Lancaster Mills in Clinton.

Under the provisions of the Metropolitan Water Act, the Board is required to let only a comparatively small stream of water run down the river below the Wachusett Dam. Below the Lancaster Mills there is but little fall in the river down to the partly demolished dam near Water Street, and the stream receives manufacturing wastes from the mills, including tar and other waste products from the works which furnish gas for the mills. The bed of the river was somewhat irregular, and the water affected by these wastes from the mills stood in places in shallow pools or was spread out among the stones of which the river bed was composed, causing an unpleasant appearance and disagreeable odors, especially during the summer and early fall. These conditions were the cause of complaint from the residents of a section of Clinton known as Germantown, near the river below the mills. A number of pipes in Germantown, carrying domestic sewage, also discharged into this part of the river channel, and it was used as a dump for tin cans and similar refuse.

In order to improve the conditions, a channel 3,750 feet long, 12 feet wide and about 1 foot deep was formed in the lowest part of the river bed, extending from the point where most of the water from the Lancaster Mills enters the river nearly to the dam near Water Street; and an extension of the channel was carried 600 feet further up the river with a width of 6 feet, to receive the water from the gas works and bleachery. The tin cans and other refuse were gathered up and buried, and the shallow pools filled with material excavated from the channel. Such trees and brush along the river banks as were objectionable were cut down and burned.

By these improvements, the flow of the river, when small, passes through the new central channel, and does not spread over the other portions of the river bed, and no complaints have been received

from the residents along this part of the river since these improvements were made. This work was begun July 18 and finished August 23. An average force of 23 men and 2 horses was employed.

Real Estate, Care and Disposal.

Rents have been collected and repairs made on houses belonging to the Board in the neighborhood of the dam and South Dike and of the Clinton sewerage filter-beds in Lancaster.

Cement Tests.

The usual tables of tests of cements used in the dam and in the masonry of the Central Massachusetts Railroad may be found in Appendix No. 2.

SUDBURY DEPARTMENT.

Desmond FitzGerald, *Department Engineer.*

The work in this department relates mainly to the maintenance and operation of the Sudbury and Cochituate works, including the aqueducts and Chestnut Hill Reservoir.

The work of construction in this department during the year has been connected almost entirely with the improvement of certain shallow arms of Lake Cochituate, known as the Pegan Brook and Snake Brook meadows, as required by chapter 509 of the Acts of the year 1901. In addition, works have been constructed for intercepting the waters of brooks flowing from the settled portions of Natick, and conveying them to a point where they can be pumped to the Pegan Brook filter-beds and purified before being discharged into the lake. Mr. FitzGerald and his assistants have also devoted a considerable amount of time to the case of the Nashua River Paper Company *v.* Commonwealth for damages caused by the diversion of the waters of the Nashua River, and to other cases.

The resignation, on November 15, of Mr. FitzGerald, and the placing of the work of his department in charge of Mr. Haberstroh, assistant superintendent, and Mr. Sherman, division engineer, have already been referred to at the beginning of my report.

Benjamin F. Goodnough, assistant engineer, has been in immediate charge of the improvements at Lake Cochituate.

The engineering force engaged upon construction has varied from 3 to 5.

The offices of this department are in Boston and South Framingham.

Improvement of Lake Cochituate.

The Act of the General Court, under which the removal of mud from Snake Brook and Pegan Brook meadows has been done, required the excavation "to be made to a level of three feet above the bottom of the aqueduct," or 10.33 feet below high water; "*provided, however*, that the amount so expended shall not exceed one hundred thousand dollars; and if the board shall find it impossible to excavate said meadows to the depth specified and to carry out all the provisions hereof for said sum, then the work shall be prosecuted to such extent as may reasonably be done for the sum of one hundred thousand dollars."

It was evident before the work was entered upon that $100,000 would not be sufficient to complete the excavation to the depth specified, and accordingly the removal of mud at Snake Brook Meadow was carried to a depth of 9 feet below high water. As the work at this point was completed for a less sum than had been anticipated, it was possible to carry the excavation at Pegan Meadow to a somewhat greater depth, and the mud was therefore removed to a level about 9.8 feet below high water. The event has demonstrated, however, that this excavation was carried somewhat too low, as the completion of necessary work has already made the total cost of the improvement about $102,000.

Snake Brook Meadow.

At the beginning of the year the excavation of mud under the contract of Long & Little was nearly finished, as stated in the last annual report, and work was then in progress. The excavation was completed early in January, and the gravel facing of the embankments was finished on January 22. The total quantity of mud excavated and placed in embankments was 52,631 cubic yards, and 5,247 cubic yards of gravel were used in facing the embankments. The maximum force employed by the contractor during 1902 was 65 men and 32 horses, on January 7.

During the winter and spring the embankments settled, and in a number of places the slopes became badly distorted. A small day-labor force was employed during October and November in placing gravel to repair these slopes, and in excavating and embanking the channel of Snake Brook from the point where the contract work

LAKE COCHITUATE—IMPROVEMENT OF PEGAN BROOK MEADOW WHEN NEARLY COMPLETED.

ceased, at the mouth of Hammond's Brook, to Main Street, a distance of about 960 feet. The channel of Hammond's Brook was also cleaned out as far as Lake Street.

Pegan Brook Meadow.

At the beginning of the year, the work of excavating a main ditch for the drainage of this meadow was in progress with a day-labor force, and was completed on February 17. Pumping was then stopped and the water allowed to rise over the meadow. The ditch was about 2,500 feet long, and extended from the northerly end of the meadow near Kansas Street to a pump well near the Boston & Albany Railroad. On April 5, although the lake was full and the water was 6 feet deep over the meadow, the pumps were started again; and on April 20 the meadow, which was cut off from the main portion of the lake by a dam, was bare. The pumps were at all times operated by the employés of the Board.

A parcel of land containing 2.95 acres, adjoining land of the Commonwealth and just north of the meadow, was purchased for use as a gravel pit, as it proved impossible to find a sufficient quantity of suitable gravel at any other point within reasonable distance of the meadow.

Four bids for improving the meadow were received on May 6; the contract was awarded to the lowest bidder, Auguste Saucier of South Framingham, Mass., at 22¾ cents per cubic yard for mud excavation and 36 cents per cubic yard for gravel excavation. He began operations on May 12, and prosecuted the work vigorously, completing it on December 20. The main-drainage ditch and the tributary ditches drained the meadow so thoroughly that excavation was carried on very advantageously. The mud, being of a peaty nature, was easily handled, and large loads were readily carried. In various portions of the work the contractor made use of wheelbarrows, carts, and cars drawn by a stationary engine; each had special advantages under particular conditions of haul, and all proved satisfactory.

Late in the autumn, when the lake had been drawn very low, the contractor was required to remove the dam separating the meadow from the lake to a point about 7 feet below the level of high water. A considerable part of this dam was composed of gravel of fair quality, which was used in facing the embankments; the remainder

was sand, which was placed on top of some of the embankments, for the double object of constructing a surface which would bear up a horse and of protecting the peaty material against fire.

The total quantity of material excavated under this contract was 157,962 cubic yards of mud and 28,543 cubic yards of gravel. The largest force employed was 162 men and 38 horses, on August 2.

When the work of excavation was in progress, the water pumped for the drainage of the meadow was thereby made unfit to be turned into the lake, and it was discharged upon the Pegan filter-beds for purification. As the quantity of water filtering through the gravel from the lake and from the land side, added to the flow of the brooks, made a very large quantity to dispose of on the filter-beds, a system of ditches and drain pipes was provided to carry the pure water to a second pump well, so that it could be pumped directly into the lake. The pumps were stopped on November 28, as all work requiring pumping was then completed.

Extension of the Pegan Brook Filtration System.

For nine years the waters of Pegan Brook have been pumped to filter-beds for purification before entering the lake. In connection with the improvements at the Pegan Brook Meadow and the need for a more efficient pumping station at Pegan Brook, it was thought advisable to intercept the waters of four small brooks which drained a somewhat thickly settled portion of Natick and discharged into the Pegan Brook Meadow, and conduct them to a small receiving reservoir to be connected with the new pumping station. For this purpose an intercepting ditch about 3,000 feet long was constructed along and near the inner edge of the embankment made for the improvement of the meadow, from a new culvert under Kansas Street to a reservoir of about 1,000,000 gallons capacity, which was excavated by the contractor for the improvement of the Pegan Brook Meadow near the site of the new pumping station.

In order to equalize as much as possible the freshet flows, the small pond north of Kansas Street was included in the system as an equalizing reservoir. The level of Kansas Street was raised by permission of the authorities of the town of Natick, and a concrete arched culvert was built under the street at the proper level for connecting the pond with the upper end of the intercepting ditch. To provide for emptying the equalizing reservoir if it should be neces-

sary at any time, an 8-inch pipe was laid under the street at a low level. Three storm overflows were also provided for wasting freshet water from the ditch into the lake whenever the pumps and reservoirs may be unable to take care of it. The works for this improvement, with the exception of the reservoirs, were built by a day-labor force. A 20-inch pipe has been laid from the bottom of the new reservoir to the location of the new pumping station, to be subsequently described under the head of Maintenance.

WESTON AQUEDUCT DEPARTMENT.

HORACE ROPES, *Department Engineer.*

The work of this department has related solely to the construction of the Weston Aqueduct, Weston Reservoir and other structures pertaining to this new conduit of 300,000,000 gallons daily capacity, extending from the Sudbury Reservoir in Southborough to a point west of the Charles River in Weston, where it connects with main pipe lines leading to the Metropolitan Water District.

During the year work has progressed actively all along the line, and much more work has been done than in the previous year.

The greater amount of work in progress this year, after the resumption of active operations in the spring, made it necessary to increase the size of the engineering force, and at the same time made it advisable to modify to some extent the organization of the force. Edward S. Larned was advanced from the position of division engineer to that of principal assistant engineer on April 1, and was given general supervision, under the department engineer, of the work and materials of construction, and acted in this capacity until early in August, when the position was abolished. On April 1 the four assistant engineers, Dan B. Clark, Frank E. Winsor, Marshall Nevers and George W. Booth, assigned to divisions of the work, were promoted to the rank of division engineers, and were placed in charge of all work on their respective divisions. The increasing amount of field work made it necessary to relieve Mr. Winsor of the supervision of the drafting work in the Saxonville office, and on March 5 Walter W. Patch, assistant engineer, was transferred from the Sudbury Department, and given charge of the records, drafting and computing at the main office. Since August 1, Mr. Patch has also directed the work of the cement-testing laboratory.

The total engineering force at the beginning of the year was 37, and in addition there was 1 masonry inspector. As the work increased additions were made, until in August the engineering force reached a maximum of 70, including 16 engineering inspectors, and there were also 10 masonry inspectors. At the end of the year the force had decreased to 58, and 3 masonry inspectors. At times a small day-labor force has been employed to do miscellaneous work.

In addition to the main office of the department in Saxonville, branch offices have been maintained throughout the year at Framingham, Wayland and Weston, for the use of the engineers of the first, third and fourth divisions, respectively.

Weston Aqueduct.

A full description of this aqueduct, accompanied by a map, was given in the last annual report. Early in 1901 contracts were made for the construction of those portions of the aqueduct which it was thought would require the longest time for completion, because of the tunnel work included therein. At the end of August in that year contracts for additional sections were let, but the season was too far advanced for much progress to be made that year. At the beginning of 1902 there were yet remaining three sections for which contracts had not been made. Of these, the contract for the steel siphon pipes and other works on sections 7 and 9 was signed on March 8; and that for laying three lines of cast-iron pipes and doing other work on Section 1, near the Sudbury Dam, was signed on June 19. This completed the main contracts for the construction of the aqueduct and reservoir, which comprised 9.14 miles of masonry aqueduct in open trench, 2.30 miles of aqueduct in five tunnels, 0.98 of a mile of steel and cast-iron pipes, and 1.02 miles of open channel and reservoir, — a total of 13.44 miles. Several other contracts of less importance were made during the year, providing for hauling cast-iron pipes from the railroad to Section 1, for a blow-off pipe and ditch leading from the siphon pipe on Section 9, and for stone superstructures at four siphon and two gaging chambers.

The progress of the work to date upon the different contracts and a comparison with the total amount of work to be done on each are given in the following tables, which show the length of aqueduct built and the value of work performed. These tables show that,

taking the contracts as a whole, 70 per cent. of the total length of aqueduct has been built, and the value of the work performed is 66 per cent. of the whole.

Table showing Length of Aqueduct built and to be built, December 31, 1902.

NUMBER OF SECTION.	Built to December 31, 1901 (Feet).	Built in 1902 (Feet).	Total to December 31, 1902 (Feet).	To be built (Feet).	Total Length (Feet).
1,	0	226	226	311	537
2,	2,449	4,127	6,576	1,861	8,437
3,	1,479	2,804	4,283	1,217	5,500
4,	3,271	879	4,150	0	4,150
5,	1,567	3,432	4,999	301	5,300
6,	841	2,294	3,135	1,383	4,518
7,	0	2,126	2,126	1,480	3,606
8,	494	2,969	3,463	0	3,463
9,	0	1,125	1,125	0	1,125
10,	0	0	0	2,923	2,923
11,	0	3,951	3,951	2,634	6,585
12,	1,264	3,149	4,413	2,087	6,500
13,	751	3,586	4,337	2,963	7,300
15,	0	3,294	3,294	2,427	5,721
Totals,	12,116	33,962	46,078	19,587	65,665

NOTE. — In estimating the length of aqueduct built, the portions of tunnels in which side lining and arch have been built are included, and three-fourths of the portions of tunnels excavated but not lined.

Value of Work done and to be done, December 31, 1902.

SECTION.	Contractor.	Date of Contract.	Amount of Contract.	Value of Work done to December 31, 1902.	Per Cent. of Work done to December 31, 1902.
1	T. H. Gill & Co.,	June 19, 1902,	$29,030 00	$20,500 00	71
2	Shanahan, Casparis & Co.,	May 9, 1901,	200,477 00	136,500 00	68
3	Shanahan, Casparis & Co.,	May 9, 1901,	127,507 50	88,500 00	69
4	Patrick McGovern,	May 6, 1901,	61,161 69	61,161 69	100
5	Bruno, Salomone & Petitti,	May 8, 1901,	129,300 00	119,300 00	92
6	Shanahan, Casparis & Co.,	May 9, 1901,	112,600 00	78,700 00	70
7 and 9	Edward Kendall & Sons,	March 8, 1902,	134,990 00	116,400 00	86
8 and 10	Winston & Co.,	Aug. 28, 1901,	146,139 00	80,000 00	55
11	Winston & Co ,	Aug. 28, 1901,	148,635 00	95,000 00	64
12	Shanahan, Casparis & Co.,	May 9, 1901,	134,096 50	95,900 00	71
13	Columbus Construction Co., successor to Michael H. Keefe,	May 20, 1901,	403,000 00	253,800 00	63
14	Nawn & Brock,	Nov. 26, 1901,	58,490 00	31,600 00	54
15	Winston & Co.,	Aug. 28, 1901,	171,645 00	97,200 00	57
Reservoir.					
1	Nawn & Brock,	Nov. 26, 1901,	59,587 50	9,900 00	17
2	Nawn & Brock,	Nov. 26, 1901,	88,292 50	38,200 00	43
			$2,004,951 69	$1,322,661 69	66

Contracts, Weston Aqueduct.

Section 1. — Headworks and Connections at Sudbury Dam.

Contractor, T. H. Gill & Co.; date of contract, June 19, 1902; amount of contract, $29,030; length of section, 537 feet, including three lines of 60-inch cast-iron pipes and 57 feet of masonry section in head-house and aqueduct.

The contractor began work promptly, and made good progress until cold weather forced him to stop operations. The value of the work performed to the end of the year was 71 per cent. of the total amount; and, while the contractor did not accomplish all that was required by the contract, the portions performed were by far the most difficult and exacting.

To be properly prepared to care for the freshet flow from the Sudbury Reservoir, it was essential that certain parts of the work should be substantially completed and ready for operation before stopping work for the winter. The contractor succeeded in attaining this result.

The work accomplished comprises the new channel with its concrete floor, masonry sidewalls — including the abutments for the arched bridge — and heavy stone paving; the laying of the three lines of 60-inch cast-iron pipes, extending from their connections with the 48-inch outlet pipes from the reservoir, for a distance of about 220 feet, to a point a short distance easterly from the chamber containing the valves which regulate the discharge from these pipes into the channel; and the completion of the outlet and valve chambers. The unfinished ends of the two lines of 60-inch pipes for the side outlets have been strongly bulkheaded, so as to permit the discharge of at least 200,000,000 gallons daily from each pipe into the channel.

The sand required for concrete and mortar was obtained from adjacent private land, while the contractor's stone crusher and rotary screen, erected on the work early in the season, furnished the necessary crushed stone.

The 60-inch cast-iron pipes and other heavy castings were put in place by a large derrick. The Board purchased and delivered on the ground all the cast-iron pipes and special castings required, amounting to 930 tons. The greater part of these had been delivered prior to letting the contract, by agreement with L. F. Childs of Framingham. He was paid $1.25 per ton for unloading the pipes

from the cars at Fayville and hauling them to convenient points on the section. The maximum force employed on this section was 73 men and 8 horses, for the week ending August 30.

Sections 2, 3, 6 and 12. — Masonry Aqueduct and Tunnels.

Contractor, Shanahan, Casparis & Co.; date of contracts, May 9, 1901; amount of contracts, $574,681; length of aqueduct, 24,955 feet, including 5,879 linear feet of tunnels. The aqueduct on sections 2 and 3 has a width of 10 feet, and on sections 6 and 12 a width of 13 feet 2 inches.

The work which was started and in progress on all these sections in 1901 has been continued throughout the year, subject only to the interruptions to open trench work due to the cold weather. The contractor has been confronted by many difficulties from time to time, and is somewhat more behind the requirements of the contracts than at the beginning of the year; but the work is still in such condition that it is possible to finish it within the required time.

At the beginning of the year, scarcely more than a start had been made in the excavation of the tunnels on sections 2 and 3. At the end of the year, tunnel No. 1, which is 704 feet long, had been excavated for rather more than half its length; tunnel No. 2, which is 3,015 feet long, had been excavated to within 5 feet of the meeting point; and tunnel No. 3, which is 2,160 feet long, had been excavated for its full length.

In tunnel No. 1, at the beginning of the year, work was in progress at the easterly portal; but, owing to the use of inefficient methods and the presence of an incompetent superintendent, the tunnel caved in several times, causing serious delays. After the caving in of the roof, on February 6, the work was completely abandoned until July 7. After other futile attempts to advance the excavation and masonry lining of the tunnel, the contractor was required, on August 16, to adopt more efficient methods, and to place the work under a more competent superintendent. Since this was done, the excavation and masonry, which have been carried on at both ends of the tunnel, have progressed smoothly and without accident until December 8, when the work was again shut down at the west end, because preparations had not been made to meet the winter conditions.

The tunnel is being excavated through a ridge of compact material which is hard to penetrate with a pick, and when freshly exposed

appears quite dry and self-sustaining; soon after exposure, however, moisture begins to gather, and the material rapidly softens and begins to run, bringing considerable weight on the timbers. The material has the appearance of clay, but it is to a large extent a very compact, fine sand.

The system of timbering used is the common form of a cap and inclined legs resting on the wall plates, which are supported by plumb posts. There is no trouble in setting the roof timbers before the ground begins to soften; therefore, with timbers of sufficient strength properly placed, and with careful attention to driving the lagging close and tight, very little complication or difficulty need be experienced in the work.

The original plans provided alternative methods for the lining of this tunnel; a brick lining was to be used if the material was to a large extent self-sustaining, otherwise a concrete lining was to be used. At the beginning of the work the brick lining was used, but it was soon found that it would be necessary to resort to heavy timbering, and the concrete lining was therefore adopted. The concrete is made with Portland cement, mixed in the proportion of 1 part by measure of cement to 2½ parts of sand and 4½ parts of broken stone or screened gravel, and is built in short lengths of from 16 to 20 feet, as the excavation of the bench advances, in this way keeping it always near the end of the work. Owing to the difficulty of placing the invert while the other work is in progress, this portion of the lining is omitted until the excavation is completed or until it becomes necessary. At the end of the year the tunnel lining had a total length of 375 feet.

For eight weeks in the latter part of the year the average total weekly progress of the excavation for both ends of the tunnel was 21 feet of full section. Excavation is suspended while the masonry is building, which in part accounts for the low rate of progress. At the end of the year 305 linear feet remained to be excavated.

Tunnel No. 2, which is 3,015 feet long, was excavated wholly through granite and diorite formations. At the beginning of the year the excavation of the tunnel at its easterly end was in progress, and excavation was begun at the westerly portal on January 20. As already stated, this tunnel was excavated for substantially its full length at the end of the year, as the headings were within 5 feet of the meeting point. None of the masonry lining has as yet been built.

Tunnel No. 3, which is 2,160 feet long, was excavated for the greater part of its length through granite and diorite formations, though for about 125 feet near the easterly end and about 50 feet near the centre of the tunnel the surface of the ledge was below the top, and the overlying earth required to be supported by timbering. At the beginning of the year the excavation of the tunnel at its westerly end was in progress, but at the easterly end the excavation of the portal cut did not reach a point where the tunnel could be begun until February 20. The heading at this point was barely started when a thaw and heavy rains caused the sides of the portal cut to slip, filling the bottom of the cut with a soft, semi-fluid clayey material, and completely blocking the work. This was not removed so that tunnelling could be resumed at this point until May 12. At the point selected for the portal the ledge had sufficient height to include the full section of the tunnel, but its surface dipped so that 60 feet in from the portal the clayey earth appeared in the top of the tunnel. This condition extended for a distance of 125 feet, and required heavy timbering to sustain the roof of the tunnel. In order to guard against any settling of the timbers and adjacent portions of the roof, the concrete lining was built from the portal to the inner end of the timbering.

In excavating from the westerly end the only special difficulty encountered was at a point about 800 feet in from the portal, where a depression in the ledge caused the work to be partly in rock and partly in boulder clay for 50 feet. This portion had to be timbered. Later, as the ground above settled, the timbers began to yield, and it became necessary to quickly secure the same by building the masonry lining through this portion of the tunnel. In all 240 feet of concrete lining were built in this tunnel during the year. The headings met on December 24, at a point 1,662 feet from the westerly portal and 498 feet from the easterly portal.

The very much smaller progress at the easterly end was due to the late date of starting the work, and to the considerable delays caused by timbering and the building of the concrete lining.

In tunnels Nos. 2 and 3 the contractor first adopted the plan of excavating a bottom heading about 7 feet high to the full width of the tunnel, leaving the remainder of the section to be removed later. After an extended trial of this method, it was decided, late in March, to be more economical to excavate the full section of the tunnel at

one time, and this has since been done. At the end of the year there remained in tunnel No. 2 690 feet and in tunnel No. 3 450 feet to be enlarged, and in addition the trimming of projecting points remains to be done in other portions of the tunnels.

All of the power required for drilling and pumping purposes in these tunnels and for running three stone crushers has been furnished by the air compressors installed between the two tunnels in 1901.

The lighting of the tunnels has been principally by gasolene lamps, though at times, and particularly when building masonry, acetylene lamps have been used with satisfactory results.

All the motive power to transport the material excavated from the tunnels has been furnished by mules, except at the westerly portal of tunnel No. 2, where the cars are raised about 30 feet above the level of the tunnel to the top of the cut, on an incline operated by a cable and hoisting engine.

At the beginning of the season for outside work there was a serious delay caused by the retesting or rejection of a large quantity of the natural cement used on these sections. The cement used the previous year in the concrete had not hardened in a wholly satisfactory manner, and cement which had been stored during the winter by the contractor, as well as that stored at the cement works, and shipped in the spring, showed much less strength on short-time tests than in the previous year. Arrangements were made as promptly as possible to get fresh and more finely ground cements, but there was a considerable delay in resuming the actual building of masonry.

On sections 2 and 3 grading and other work pertaining to the construction of the aqueduct in open trench was resumed about April 1; but the actual building of masonry was not begun until May 1 on Section 2, and May 13 on Section 3. The work proceeded slowly during the season, and the total length of aqueduct outside of tunnels completed during the year on Section 2 was 1,729 feet and on Section 3 1,316 feet.

There has been a considerable increase in the plant during the year: sand bins with a rotary screen and conveyor, operated by steam, have been erected at the Brewer sand pit, to supply sand for sections 2 and 3; a No. 5 Gates crusher, with conveyor, rotary screen, bins, etc., and run by a 50 horse-power engine, has been set up on the waste dump at the west end of tunnel No. 2; a crushing and mixing plant has also been erected at the west end of tunnel

No. 3, — it includes a 16 horse-power engine, jaw crusher, conveyor, screen, large stone bins and a 4-foot cubical mixer. These crushers have been operated intermittently to furnish stone as required for the masonry in progress.

The dimension stone headwalls for all the culverts on sections 2 and 3 were completed early in the season.

The proportion of the value of the work done to the full amount of the contract is substantially the same on each of these sections. At the end of the year only 69 per cent. had been completed, instead of 84 per cent. of the total, as required by the contract.

On Section 6 a small force was engaged during the winter months in making the Elm Street embankment, excavating muck from the swamp at the westerly end of the section and hauling bricks. Trench excavation and other work preparatory to masonry construction were actively resumed about the middle of March, and concrete masonry would have been started before April 1 had the cement on hand been acceptable. By using a leaner Portland cement concrete for the natural cement concrete specified, until the proper quality of natural cement could be obtained, the contractor began building concrete masonry on April 2. The work on this section has been carried on in a satisfactory manner, but the rate of progress has not been equal to that required by the contract, so that the deficiency noted in the last annual report has been slightly increased. On December 31 the value of the work completed was 70 per cent. of the total, and in point of time may be said to be about six weeks behind time. There have been 3,135 linear feet of aqueduct built, including the whole of the easterly half of the section and the substructure of the siphon chamber; 1,383 feet remain to be built.

The material excavated on this section has been nearly all extremely hard to dig, and it has consequently been difficult to excavate the trenches rapidly. So little excavation remains to be done that the work should progress more rapidly in the future. A larger proportion of the trench than was anticipated has proved suitable for the use of the compact earth type of aqueduct, which requires less masonry than the ordinary type, and it will reduce the cost of this section somewhat below the preliminary estimates.

The only work of an exceptional character that has occurred on this section has been the excavation of peat and mud to a depth of 12 feet where the aqueduct crosses a swamp for a distance of 250 feet.

The bottom of this excavation was in fine material, and, on account of the considerable quantity of water encountered, was difficult to excavate. The pit was refilled with earth spread in 3-inch layers, which were compacted by rolling, and watering if necessary, so as to make a suitable foundation for the aqueduct. The water was removed from the excavations by a 4-inch centrifugal pump. One stone crusher was run steadily, and for a part of the time a second crusher has been operated, to furnish stone for the concrete.

On Section 12 work has been in progress throughout the year. Prior to April 1, when work was resumed on the line of the aqueduct, a small force had been employed in quarrying and crushing stone and distributing it along the line, also in hauling a supply of bricks for use in the work.

In the early part of the season there was considerable delay, owing to a decision to adopt mechanical devices instead of hand work for various operations.

Commencing with a force of 50 men, the number was gradually increased to 100 men in the middle of June.

The erection of a screening and concrete mixing plant was begun about the middle of May, and it was ready for operation five weeks later. Toward the latter part of July a cableway near the easterly end of the section and a gravity screen near the westerly end were ready for operation, and the number of working points was thus increased to great advantage. After the work was well started the progress was substantially that required during the second season of the work, but at the end of the year the deficiency was somewhat greater than at the end of the previous year. On December 31 the value of the work done was 71 per cent. of the whole, and the work appeared to be about seven weeks behind the requirements of the contract.

At the end of the year 4,413 feet of aqueduct had been completed, and 2,087 feet remained to be completed. The most rapid progress was made in October and the first half of November, when the average weekly rate for seven weeks was 132 feet of completed aqueduct. The greatest weekly rate for any week was 180 feet.

The earthwork upon this section has generally been easily handled material, and much of it was gravel and sand of good quality for concrete. At the easterly end of the section, however, a very fine sand is encountered toward the bottom of the trench, and consider-

able water enters the trench at this place. The aqueduct rests on a double platform of 1-inch spruce boards, of which the top layer was fluted, extending over the entire bottom to form a dry foundation on which to lay the concrete. Drainage was facilitated by the flutings which were on the under side of the upper boards, and connected with a longitudinal box drain laid in the middle of the trench. The brick lining of the invert was also made with two rings of bricks, instead of the single ring used in most places, in order to withstand the upward pressure of the ground water.

On all four of these sections the skimcoating of the arch has been in progress, and at the end of the year about 8,600 linear feet had been completed.

The maximum force employed on these sections was 437 men and 89 horses, for the week ending September 27.

Section 4. — Masonry Aqueduct.

Contractor, Patrick McGovern; date of contract, May 6, 1901; amount of contract, $61,161.69; length of aqueduct, 4,150 feet; width, 10 feet.

Work under this contract was resumed early in April, and was continued to completion in August, about one year earlier than the time required by the contract. The work was not only done expeditiously, but in a very satisfactory manner. The maximum force employed during the year was 72 men and 11 horses, for the week ending May 24.

Section 5. — Masonry Aqueduct.

Contractor, Bruno, Salomone & Petitti; date of contract, May 8, 1901; amount of contract, $129,300; length of aqueduct, 5,300 feet, including crossing under the tracks of the New York, New Haven & Hartford Railroad at Nobscot station; width of aqueduct, 13 feet 2 inches.

Work under this contract was resumed on March 31, and continued throughout the year with a rate of progress well in advance of the requirements of the contract. The special section of aqueduct which crosses under the New York, New Haven & Hartford Railroad near the Nobscot station has been completed, and there remain but 300 feet of aqueduct masonry to be built, for which the trench excavation is nearly all made. The trench excavation has been generally harder than that of the previous year. The deep cut toward the westerly end of the section was nearly all through a boulder clay, and a small depth of ledge found in the bottom of the cut

caused considerable delay, as the small depth and limited quantity did not warrant the use of steam drills. On the whole, the work progressed rapidly and satisfactorily. The material in the excavations has been sufficiently compact to permit the use of a greater length of the compact earth type of aqueduct than was considered probable when the preliminary estimates were made, and there will consequently be a corresponding reduction in the total cost of the section.

In addition to the stone-crushing plant, which has continued in nearly constant operation, two gravity screening plants were built to obtain material for the concrete. A small combined derrick and hoisting engine, mounted on wheels, was used to good advantage to handle the excavation from the deep cut west of Water Street.

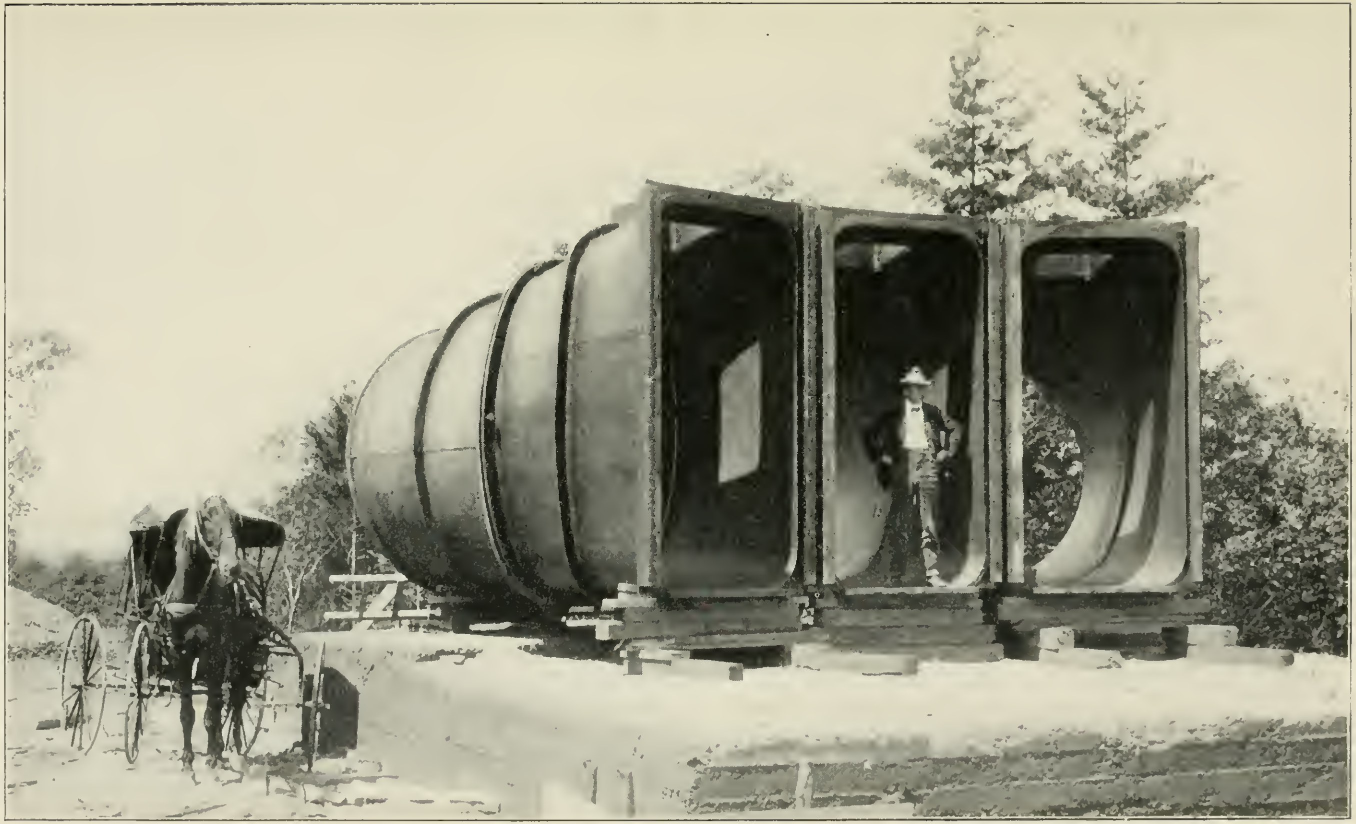
The maximum force employed on this section was 125 men and 22 horses, for the week ending June 14.

Sections 7 and 9. — Riveted Steel Pipe Lines, including Bridge over the Sudbury River.

Contractor, Edward Kendall & Sons; date of contract, March 8, 1902; amount of contract, $134,990; total length of pipe lines, 4,731 feet.

Sections 7 and 9 comprise single lines of 7½-foot diameter riveted steel pipes, forming inverted siphons across the valleys of the Sudbury River and Happy Hollow, respectively. Three lines of these pipes will ultimately be required, but one will convey about half as much water as the capacity of the aqueduct, and will meet the requirements for quite a long period. The pipe on Section 7 has a length of 3,606 feet, and that on Section 9 of 1,125 feet.

The pipes are made in the shop in 30-foot lengths of 4 plates each, except where curves or other special requirements made it necessary to use shorter lengths. The plates are about 91 by 290 inches in size, each plate being sufficiently long to make the full circumference of the pipe and a sufficient lap for riveting. The pipes are made with alternate large and small courses, the small courses having an inside diameter of 7½ feet. The plates are all 7/16 of an inch thick, except in the portion of the pipe which is to be built as a self-sustaining arch over the Sudbury River, where ⅝-inch plates are used. This arch has a span of 80 feet and a rise of 5½ feet, and springs from substantial granite-faced concrete masonry abutments.



WESTON AQUEDUCT — SIPHON CHAMBER CASTINGS AT CONNECTION OF MASONRY AQUEDUCT AND 7½-FOOT STEEL PIPES IN WAYLAND.

The shop work is done at the plant of the contractor in Cambridgeport, the plates being furnished by the Central Iron and Steel Company of Harrisburg, Pa. The riveting is done by hydraulic machines exerting a pressure of about 80 tons on each rivet. Calking is done with pneumatic tools. After a 30-foot section is made up, it is subjected to a water pressure of 75 pounds to a square inch, and made tight, after which it is dipped vertically in a bath of mineral rubber asphalt pipe coating, heated to a temperature of about 500° F. After being coated, the pipes are hauled on wagons to the railroad and shipped to Saxonville, where they are again loaded on a special wagon hauled by six horses and delivered on the work. The weight of a 30-foot section is about 8 tons. The pipes are delivered at points where they can be conveniently rolled on to a small steel-framed truck, running on a track laid in the trench, and are then hauled into place by a hoisting engine and wire cable.

The field equipment for pipe work consists of two 25 horse-power upright boilers, one small Knowles air compressor, one hoisting engine, track and car, an air pipe line: two Boyer riveting machines, 4½-inch stroke, running 800 strokes per minute, with pneumatic holding-on tool; two Boyer calking machines, with ⅞-inch cylinder, 1¾-inch stroke, running 1,500 strokes per minute; forges, jacks and small tools. Practically all the riveting and calking in the field have been done with pneumatic tools.

All pipe lines before completion and acceptance are filled with water and made tight under a pressure equal to the maximum working pressure when the aqueduct is in use. This has required an additional plant of boiler, pumps and pipe lines for short periods of time.

The contractor immediately after the award of the contract arranged with Winston & Co., who are building the adjacent sections 8 and 10, to do all work except furnishing and laying the steel pipe.

The Section 8 camp, which was established last year, was enlarged to accommodate the increased forces. Clearing was begun on April 1, and the earthwork was prosecuted vigorously. The pipework on Section 9 was started first, the plant began to arrive on June 10, and the first section of pipe was delivered on June 30. The work progressed very slowly during the summer and early fall, and the section was not completed, tested and accepted until November 10. Considerable difficulty was experienced in obtaining water for test-

ing, and, after abandoning an attempt to get water by driving wells near by, a pipe line about 3,000 feet long was laid to Dudley Pond, and the supply pumped from there.

On Section 7 much better progress has been made with the pipe-work. The first pipe was set October 1, and on November 25 1,651 feet of pipe line had been completed, tested and accepted. In addition, 480 feet of pipe had been laid and partially riveted when the season's work closed on November 29. Work on the Sudbury River bridge abutments was begun about the middle of August, and on December 1 the abutments were sufficiently advanced to receive the pipe bridge. The plant for this work consisted of an 18 horse-power double-drum hoister, running a large derrick set up on a coffer-dam in the middle of the river, and a horizontal Worthington duplex pump for keeping the water out of the pits for the foundations. The stone and sand for concrete was obtained from the screening and crushing plant on Section 8.

Blow-off from Section 9.

Contractor, T. Bruno; date of contract, October 13, 1902; amount of contract, $2,191.94.

In order to empty the existing and future steel pipes at Happy Hollow, it was necessary to provide means for conveying the water for a considerable distance. This was accomplished by laying under this contract 482 feet of 12-inch cast-iron pipe in a trench about 10 feet deep, and 392 feet of 24-inch vitrified pipe in a trench from 5 to 7½ feet deep, and by excavating for a distance of 1,800 feet a ditch 1 foot wide on the bottom and generally about 2½ feet deep and 11 feet wide on top. About 750 feet of this ditch are faced with a 6-inch layer of screened gravel, and about 24 feet with dry rubble-stone paving. These channels take the flow from the pipe to a small stream in the Sudbury Meadows, through which it finally reaches the river.

Work was begun on October 22, carried on energetically and in a satisfactory manner, and completed on November 20, ten days ahead of the time required by the contract. The maximum force employed on the work was 33 men and 3 horses, for the week ending November 8.

Sections 8, 10, 11 and 15. — Masonry Aqueduct and Tunnel.

Contractor, Winston & Co.; date of contracts, August 28, 1901; amount of contracts, $466,419; length of aqueduct, 18,692 feet, inclusive of three siphon chambers on sections 8 and 10, and the screen and terminal chambers and 600 feet of tunnel on Section 15; width of aqueduct, 13 feet 2 inches.

As mentioned in the last annual report, these contracts were let too late in the season of 1901 for much to be accomplished before the end of that year. No masonry was built except on Section 8, where about 500 linear feet of aqueduct were completed before the end of the season. During the winter, while making plans for the work, the contractor concluded that it would be advisable to use a much more extensive plant and more machinery than had hitherto been used in the construction of the aqueducts; and he presented plans for a central crushing, screening and concrete mixing plant to be used on each section, with a system of tracks to be used for conveying the materials to be screened and crushed to the central plant and the concrete from the central plant to working points. As the system adopted and the plant installed on these sections appear to represent an important advance as regards economy over the methods heretofore used, they will be described subsequently at some length.

Sections 8 and 10 are included in one contract, but, as the plant set up on Section 8 could not be moved to Section 10 so as to begin work on that section before cold weather, the contractor has not attempted to do much more than complete the work on Section 8 this year, leaving the bulk of the work on Section 10 for the coming year.

On Section 8 all of the masonry, comprising the substructures of two siphon chambers and 3,413 linear feet of aqueduct, has been built. The earthwork is well advanced, though considerable yet remains to be done towards widening embankments to their full width and covering them with loam.

On Section 10 the ground has been cleared of trees and brush, all the depressions below the grade of the aqueduct have been filled with suitable material carefully compacted to form a firm foundation for the masonry, all the cast-iron pipe culverts have been laid, and the grading for the construction railroad has been nearly finished. This preliminary work represents a small proportion of the total value of the work, but it makes it possible to make rapid progress the coming season.

On Section 11 the route of the aqueduct was cleared during the winter and the logs were hauled to a sawmill and converted into ties and lumber for use in the work. About March 1 the contractor leased buildings and land from Francis Shaw, near the crossing of the aqueduct and electric railway, and proceeded to build quarters for men and stock, establishing his central camp at this place. Early in April, as soon as the weather would permit, a large force of men and teams began the work of excavation and embankment, the work being done with special reference to preparing a road-bed for 4,000 feet of double-track construction railroad. The work of providing and erecting machinery was also pushed forward as rapidly as possible; but, owing to delays which often occur in the delivery of machinery, the plant was not ready for use until June 24. Among other causes which contributed somewhat to the delay was the burning, on the night of May 17, of a house used by the contractor as an office and storehouse, causing a total loss of a full stock of shovels, tools, harnesses, cordage, blocks and other supplies. After the plant was ready to operate, the work was carried on so expeditiously that 3,951 linear feet of aqueduct were completed on December 5, when the cold weather made it necessary to cease work. Grading operations were continued until the end of the year, and the embankments over this portion of the work were nearly completed. It is the intention to move the crushing, screening and mixing plant during the winter to a point toward the westerly end of Section 11, where it can be used for building not only the remaining 2,650 linear feet of aqueduct to be built on Section 11, but also a portion of the aqueduct on Section 10. On the westerly portion of Section 11, as well as on the easterly portion of Section 10, substantially all the preparatory grading has been done, so that rapid progress should be made as soon as the weather permits the resumption of work in the spring.

On Section 15 some excavation from rock cuts and the tunnel proceeded without serious interruption during the winter. The excavation of the tunnel, 600 feet in length, was started on January 9, and the heading, which was driven entirely from the easterly end, was completed May 2, when the work was discontinued, leaving 192 feet of bench to be excavated at times during the summer when the rock could be conveniently used at the crusher. The same general conditions which prevented an early start on the construc-

tion of the masonry on Section 11 existed on Section 15, and it was not until May 23 that the construction of the aqueduct was begun. The masonry work has been confined to the easterly half of the section, and 2,844 linear feet of aqueduct and about two-thirds of the substructure of the terminal chamber had been built before cold weather compelled a cessation of work on December 5. The greater part of the trench has been dug through massive ledges of granite and trap rock, and the progress has necessarily been slow. The earth on this section also has been very hard to dig. Progress on the brick lining was greatly retarded for some weeks by the failure to secure a sufficient number of brick masons, and this in turn prevented the building of the arch and the grading of the embankments. This contract includes some excavation and shore protection at, and the construction of a portion of the dam of, the Weston Reservoir. About half of this work has been done.

The value of the work done on all these contracts has been much less than the amount stipulated in the contracts, as at the end of the year the value of the work performed on sections 8 and 10 was 55 per cent., on Section 11 64 per cent., and on Section 15 57 per cent. of the total; while the amounts required by the contracts at that time were, respectively, 80, 80 and 82 per cent. With the methods employed, however, the providing of the plant was an important part of the work, and rapid progress should be made on all sections during the coming year. On Section 15, as already stated, the excavation has been difficult; but on the other sections it has generally been excellent, and has furnished a large proportion of excellent concrete stock. No water has been found in the trenches on any of the sections.

The maximum force employed on these sections was 399 men and 93 horses, for the week ending September 20.

Plant.

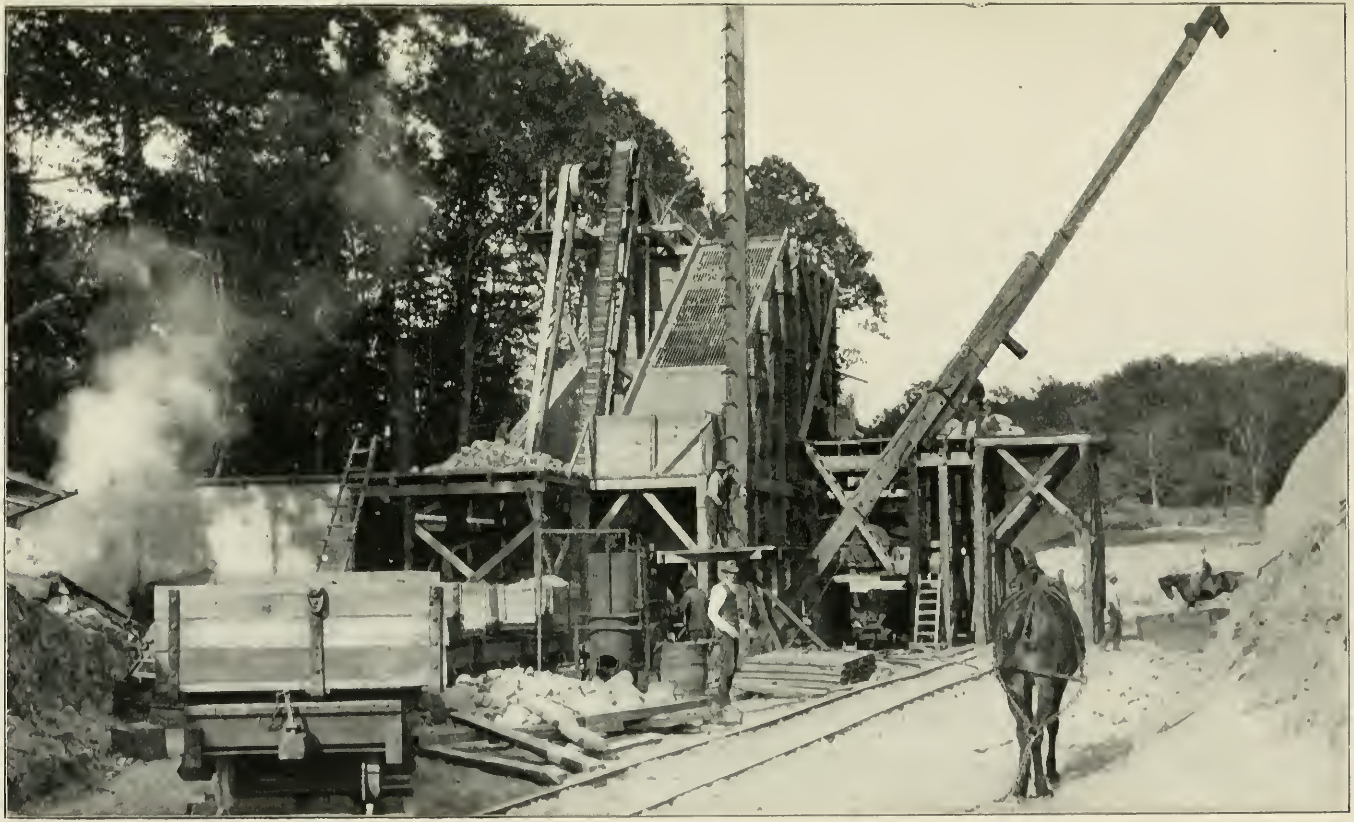
The main purpose in arranging the plant on these sections has been to so plan the work that large mechanical concrete mixers could be used to good advantage; but on Section 11, where a large amount of good sand and gravel would be available from the excavations, it was also the purpose to bring suitable material from all parts of the trench to the screening and crushing plant.

In order to transport the concrete quickly and all materials eco-

nomically, it was necessary to use cars and tracks for transportation instead of carts.

The plant on Section 11 is somewhat more complete than on other sections, and will be described in some detail. The central feature is the crushing, screening and mixing plant (shown by the accompanying illustration), which was compactly arranged with the necessary engines and boilers, in the middle of the easterly 4,000 feet of the section. The section includes much sidehill work, and by building the aqueduct embankment on its lower side about to the top of the sidewalls a road-bed was furnished much of the way for a double-track railroad. For the remainder of the distance the road-bed was provided by cutting through the higher ground to a sufficient width for the tracks. The grading for the tracks required a large amount of work, but nearly all was work required under the contract. The tracks were 3-foot gage, laid with 30-pound rails. The cars were hauled in part by mules and in part by a 7-ton locomotive.

At the central plant large bins for sand and broken stone or screened gravel, supported by heavy framed timbers, were built at a proper elevation to allow these materials to run from the bins to the mixing platform, thence into the concrete mixer, from which the concrete was dumped into steel dump cars of triangular section. A large derrick, fitted with a bull wheel and with a boom of sufficient length to reach well above the bins, lifted "skips" loaded with stone for the crusher to a low platform just at the level of the top of a No. 5 Austin crusher, or with gravel to be screened, to the top of inclined stationary screens. The stone was fed to the crusher by attendants and discharged into an elevator which lifted it to the top of the bins, where it entered a rotary screen, and the acceptable material dropped into the stone bin, while the rejected large stones ran through a shute to be again crushed. The material dumped on the stationary screens was separated so that the sand was discharged into a bin beneath, screened gravel of suitable size into an elevator which carried it to the stone bin, and the larger stones at the mouth of the crusher. As the sand bin beneath the inclined screen was too low to deliver its contents directly to the measuring platform, such sand as was suitable for the concrete was permitted to drop into "skips" on cars run under the bin, the "skips" being hoisted by the main derrick and dumped into the main sand bin. Surplus or unsuitable sand was similarly dropped into cars or carts and hauled to the embankments. The cement was hoisted in large quantities at a



WESTON AQUEDUCT—CRUSHING, SCREENING AND CONCRETE-MIXING PLANT.

time by the derrick to the platform over the mixer. This platform was about 16 feet square, and gave room for the three men employed there as well as storage space for a supply of cement. The large conical hopper connected with the mixer below was set with its top flush with the platform. This hopper could be closed by a swinging door at the bottom. The proper quantity of stone was run directly into the hopper and levelled off to a guide mark on the sides, then the proper number of bags of cement was emptied and spread over the stone. The sand was measured by drawing it into a measuring box hung on trunnions and then tipped into the hopper and spread evenly over the cement, after which the whole charge was dropped into the mixer. Water was measured by a small steel tank fitted with a glass gage, and was admitted to the mixer by pipe connections through the hollow shaft on which the mixer revolved. The batches as mixed contained about 30 cubic feet of concrete. From 25 to 30 revolutions of the mixer were required to be made, after which the concrete was discharged into the steel car for transportation to the work.

For masonry in the bottom of the trench it was possible, by means of steel shutes, to dump the concrete from the car directly into the trench. For masonry in the sidewalls and arch the concrete was first dumped from the car to a platform and then rehandled into place with shovels and wheelbarrows.

Under favorable conditions the daily capacity of one of these mixing plants was about 150 cubic yards, but the quantity actually placed in the work was ordinarily not much more than 100 cubic yards per day.

For the excavation of a part of the trench a travelling derrick was used, which lifted the "skips" after they had been loaded to flat cars to be hauled to the central plant, if the material was suitable for concrete, otherwise to be hauled to another travelling derrick which dumped them upon the embankment over the arch.

During the latter part of the season, after this plant had been operated for a sufficient time to give the necessary experience, the aqueduct was built very rapidly. The average rate of progress for nine weeks at this time was 216 feet per week, and the greatest progress in any one week was 270 feet.

On Section 8, where there was very little excavation from the aqueduct trench, and excellent opportunities for obtaining large quantities of suitable material for the concrete from borrow pits

near the central plant, the material was all hauled to it by teams, and a single track along the line of the aqueduct was used to convey the concrete from the plant to the work.

On Section 15, where there was very little if any sand or gravel, the plant was located near the middle of the section, and near a large pile of rock which had been excavated from the tunnel. In this case, also, only a single track was required to carry the concrete from the plant to the work; but, in addition, the ground was so rough that it was necessary to build a road for carts the full length of the section.

The successful use of so much machinery in building aqueducts is largely dependent upon the continuity of operations, a stoppage at any point affecting the whole work. On these sections, while there have been some delays by the breakage of important portions of the machinery, the work has been carried on so as to make very good progress. At the plant on Section 8, where there was very little stone to break, and it was necessary to depend almost wholly upon the screening of gravel, there was considerable delay in wet weather on account of the difficulty of screening wet material. At Section 11 there was sufficient stone, so that the progress was not materially interrupted by the wet weather.

The quality of the product obtained from the cubical mixer is better than that obtained by thorough hand mixing; but, as there is a tendency toward the separation of the materials when dumped from cars, on account of the large stones falling out first without a fair proportion of mortar with them, and as the quantity of concrete supplied by the mixer is so large in proportion to the size of the structures in which the concrete is placed that it is difficult to place it properly as fast as it comes to the work, the final results are little if any better than those obtained by hand mixing, and continual watchfulness on the part of the inspectors is required in order to get even as good work.

Section 13. — Masonry Aqueduct and Tunnel.

Contractor, Columbus Construction Company, successor to Michael H. Keefe; date of contract, May 20, 1901; amount of contract, $403,000; length of aqueduct, 7,300 feet, of which 5,686 feet are tunnel and 53 feet are open channel; width of aqueduct, 13 feet 2 inches.

Work in the tunnel has been continued day and night throughout the year, subject only to interruptions of about three days each at

the Fourth of July, and Christmas holidays. At the end of the previous year the tunnel had been excavated for 530 feet at the westerly end and 471 feet at the easterly end, and the amount of progress, largely on account of conditions stated in the last report, was 559 feet less than the contract requirements at that time. The conditions met with in the first 530 feet of tunnelling from the west end, caused by the lower half of the tunnel being in ledge and the upper half in earth, were also described in the last annual report. These conditions continued until about the middle of April, when the ledge rose above the roof of the tunnel, and the full section has been in rock since that time. The length excavated through this difficult portion has been 400 feet. From time to time the strength of the timbers used to support the roof was found to be inadequate, particularly of the timbers first put in. Many of them crushed and sagged, and had to be braced with props or reinforced by additional sets. The first timbers used were a cap and two batter posts 8 inches square, set from 4 to 5 feet between centres; later, 10-inch by 10-inch timbers were used, and finally 10-inch by 12-inch hard pine timbers. During the latter part of the time also 3-inch planks were used for lagging. For the last 300 feet wall plates were used as a footing for the batter posts.

Early in January the excessive settlement of the timbers at places emphasized the necessity of immediately building the masonry lining through some of the worst portions; and to meet this exigency the contractor was permitted to use brickwork instead of concrete for about 75 feet, as his preparations for the latter class of work were far from ready. Brickwork was also better adapted to these places, because many timbers obstructed the work and had to be moved, and this could be done with greater safety by building the arch in very short sections, which was not practicable with concrete.

The contractor was strongly urged to hasten the trimming of the tunnel and other preparations for concrete work, but these proceeded very slowly. Scarcity of labor and slow delivery of equipment were given as reasons for the delay, and the placing of concrete was not started until May 12. Before the concrete was placed throughout the whole of the timbered portion of the tunnel it was necessary to use props to support the timbers in many places, and for considerable lengths to retimber the tunnel. The progress of the portion of the tunnel where timbering was required was necessarily retarded,

and even after this portion of the tunnel had been passed and the excavation was wholly in rock, the trimming of the tunnel, retimbering and masonry construction impeded the progress somewhat. Notwithstanding these difficulties, the earnest efforts of the contractor have resulted in a progress in tunnel excavation somewhat in excess of that specified for the year 1902, as the deficiency of 559 feet at the end of 1901 was reduced to 463 feet at the end of 1902. This deficiency in the amount of tunnel excavation is in comparison with the progress required by the contract, but, as an additional two months has been allowed the contractor for the completion of the contract, on account of the difficulties met with in the westerly drift of the tunnel, it cannot be said that there is any deficiency in the progress of the excavation at the present time.

The total length of tunnel excavated to December 31 was 4,903 linear feet, of which 2,278 feet are in the west drift and 2,625 feet in the east drift. The average weekly progress for the year 1902 has been 75 feet.

The amount of concrete lining built at the end of the year was 1,414 feet, all in the west drift of the tunnel; and thus far only the sides and arch have been built, the invert being left until such time as the tracks can be taken up. The progress of the concrete lining is far behind the requirements of the contract.

The tunnel excavation has been through massive granite and diorite formations, which vary locally in structure and hardness. When seamy and blocky the rock has been troublesome to drill, and when hard it has required a large amount of powder to blast it.

The quantity of water draining into the tunnel is comparatively small, although sufficient to drain wells and springs in its vicinity.

After March 1, as the weather became warmer, delays due to the smoke of the powder remaining in the heading, owing to poor ventilation, became frequent, especially in the easterly drift, and the contractor was advised to resort to artificial ventilation. A quantity of 10-inch galvanized sheet-iron pipe and two blowers with electric motors were ordered. The arrival of this apparatus was very much delayed, so that the ventilation remained defective for a long time. Some advantage, however, had been derived in the mean time from the use of another form of explosive, which generated less gas and smoke.

At the westerly end of the section, where there was only a short

length of aqueduct to be built in open trench, a derrick was set up and excavation begun early in June, and three weeks later the first invert was laid. This work progressed very slowly, as the aqueduct was extended in short stretches, so that the excavation and back-filling should both be within reach of the derrick; and it required nearly the whole season to build the 236 feet of aqueduct which could be built without encroaching on the space required for the operations at the tunnel. The trench was about 15 feet deep, and, as there was considerable water in it, constant pumping was necessary. A double board platform with central box drain and a brick invert two rings in thickness were used, as described for the easterly end of Section 12.

Only 162 feet of aqueduct remain to be built at the westerly end of the section. At the easterly end there are 1,100 linear feet of aqueduct and a substructure of a channel chamber to be built in a very deep trench, much of which is to be excavated in rock. On account of the large amount of work, many requests were made of the contractor to make an early start upon this portion of the work, but there has been much delay.

Preliminary work on the plant began about the middle of July, but actual excavation at the easterly end of the section was not under way until August 9. After this date the work progressed very slowly, and the trench was not completed at any place until the very end of the season, when it was too late to build much masonry. A 16-foot length, however, was built before the cold weather required the cessation of work. The backward condition of this portion of the work will make it necessary to use very energetic efforts to complete the work within a reasonable time. The contractor has been asked to continue the work of excavation through the winter.

At the end of the year the work to be done comprised about 24,000 cubic yards of excavation from a trench 900 feet long, having a depth of 30 feet, and the construction of the aqueduct and the substructure of the channel chamber.

During the year the following additions have been made to the plant: two large derricks and hoisting engines; an inclined track, operated by hoister and cable, has been substituted for the derrick at the east portal; another 125 horse-power boiler has been added to the compressor plant; and two No. 4 Austin crushers, with conveyors, screens, etc., all run by 30 horse-power electric motors.

One crusher is located near each end of the tunnel, and is provided with an elevated stone bin and a sheltered mixing platform and sand bins. Steam pipes pass through the sand bins for use in freezing weather.

The maximum force employed on this section was 229 men and 13 horses, for the week ending October 25.

Section 14, Open Channel. — Sections 1 and 2, Weston Reservoir.

Contractor, Nawn & Brock; date of contracts, November 26, 1901; amount of contracts, $206,370; length of three sections, 5,347 feet, including about 1,347 feet of open channel, 66.6 acres of reservoir and channel, and an earth dam 900 feet long with concrete corewall.

The contractor entered on the work early in March, but the remainder of that month was consumed in the erection of camp buildings, and the actual work of construction was not started until April 1. The organization of forces, preliminary work of road building, track laying and installation of plant went on slowly, so that comparatively little was done until late in May. During this time, and pending the delivery of the steam shovel, gangs of men were employed in clearing and burning brush, grubbing stumps, stripping loam from portions of the reservoir site and storing same in piles for future use, grading a temporary relocation of Ash Street, making a paved drainage ditch on the north side of the open channel and reservoir, stripping ledge and preparing foundation for the corewall at the dam, and making excavations from the reservoir with men and teams. A new steam shovel which had been promised some weeks earlier was not ready for operation until May 28, when it was put to work near the easterly limits of Section 1.

Brief observation of the daily working of this shovel showed that it could not make the desired rate of progress, and the contractor was advised to adopt some other measures to increase his output. He decided to provide a second steam shovel, and no time was lost in ordering the same, but it was not put into commission until late in September. The output for each of these shovels for the period they have been working has averaged about 500 cubic yards for ten hours, which falls far short of the amount necessary to advance the work at the rate stipulated.

On Section 14 the open channel and reservoir excavation are well advanced. The material from the excavations is being deposited in extensive mounds, designed by Olmsted Brothers, landscape archi-

tects, which are to be regraded to required contours and covered with loam, so that they will resemble natural mounds. The mound north of the open channel will cover 9¾ acres to an average depth of 5 feet, and the highest point will be 20 feet above the natural surface of the ground. It is designed to contain about 80,000 cubic yards. Material from Section 14 has been dumped at this place, and the mound is very nearly half made. All the loam has been removed from the site of this mound. Some of it had to be stored in spoil banks to be rehandled, but by careful management it has been possible to spread as much as half of the loam directly in place with only one handling.

The smaller filling north of the reservoir and east of Ash Street has been completed with material excavated mostly from Section 14. This fill covers 5 acres, has an average depth of 3 feet and contains 27,000 cubic yards. None of the soil beneath it was removed, as there was sufficient soil dressing from the reservoir which could be hauled directly to place.

Nothing has been done on the ground toward the stone arched bridge over the open channel at Ash Street. The paved drainage ditches are very nearly completed, 2,900 linear feet having been built.

The value of the work done on this section was 54 per cent. of the total value, which was only about two-thirds of the amount required by the contract.

On Section 1 the total excavation is estimated to be 230,000 cubic yards, of which only 37,000 cubic yards had been made at the end of the year. This material has gone mainly into the large mound to be built on the south side of the reservoir, and which when finished will contain 210,000 cubic yards. At the end of the year only 17 per cent. of the total value of the work had been finished, where 79 per cent. was required.

On Section 2 70,000 cubic yards of soil stripping and excavation had been done, out of a total estimated amount of 177,000 cubic yards. This excavation has been placed in two small embankments south of the reservoir, which are now substantially completed; in the small embankment at Cooper Cove on the north side of the reservoir; and in the embankment of the dam. About 1,100 feet of shore line have been dressed to slopes, and riprap placed upon them.

The work done on the dam includes the removal of earth and loose materials so as to expose the ledge for a width of 25 feet and length of 700 feet along the line of the corewall, preparing the foundation of the corewall and inner portion of the earth dam by removing all loose and seamy rock from immediately under the corewall, and by carefully scraping and washing out the seams over the whole width of exposed ledge, then filling the seams with rich Portland cement mortar, and finally coating the whole surface of the ledge with a cement wash. The 16-inch cast-iron waste pipe from the lowest part of the dam has been laid. The corewall has been partly built for a length of 439 feet. For 233 feet of this length, including the deepest portions of the dam, the top of the corewall is up to elevation 185.5, which is 14.5 feet below full reservoir level, and for the remaining 206 feet is up to elevation 192. The portions of the earth dam on both sides of the corewall, which, by the specifications, are to be built of selected materials spread in layers, wet and rolled, have been built about to the same elevations as the corewall. Considerable filling has been done in the portions of the dam where, to increase its thickness and give it the form required by the plans of the landscape architects, much waste material and loam are to be dumped.

The excavation for the concrete drain 4 feet in width and height along the northerly shore of the reservoir was begun about the middle of June. The first concrete was laid July 2, and the work was continued until late in November, when 1,374 linear feet had been built. The material through which the trench for the drain was excavated was very hard, a large part of it being ledge. Across Cooper Cove a rolled embankment had to be built to make a foundation for the drain. There remain 893 feet of drain to be built.

On December 31, 43 per cent. in value of the work on Section 2 had been done, which was about half the amount required at this time by the contract.

Although the work on these three sections has at all times been far below the requirements of the contracts, the contractor was not urged very strongly during the summer and autumn to increase his force, because it was known that he had a very large organization at the Wachusett Reservoir on work which would be substantially finished at the end of the year, and that on the completion of that work he could increase very much the organization at the Weston

Reservoir, where there is abundant opportunity for working a large force. At the end of the year, however, the work was so seriously behind time that much more activity must be shown to finish the work as soon as required.

In addition to the two 45-ton Souther steam shovels before mentioned, the principal items of plant upon these sections have been as follows: 3 12-ton and 1 6-ton locomotives, 40 dump cars of 3 cubic yards capacity, 2 miles of track laid with 30-pound rails, 8,600 feet of wrought-iron pipe from 1 to 2 inches in diameter, 1 derrick and hoisting engine and a gasolene engine and pump.

The maximum force employed on these sections was 237 men and 36 horses, for the week ending July 5.

Superstructures of Siphon and Gaging Chambers.

Contractor, Norcross Brothers Company; date of contract, December 18, 1902; amount of contract, $27,352.

These superstructures are to be built of stone. The superstructures of the siphon chambers are located at the ends of the Sudbury River and Happy Hollow siphons, and of the gaging chambers on sections 2 and 5 of the aqueduct. Under the terms of the contract the contractor is not required to begin the erection of these buildings before April 10, 1903, although it is expected that the necessary preparatory work will be done during the winter and early spring.

Work Done and Materials Used.

The principal items of work done and to be done in the construction of the Weston Aqueduct and Reservoir are given in the following table: —

ITEM.	Total Estimated Amount (Cubic Yards).	During 1901 (Cubic Yards).	During 1902 (Cubic Yards).	To Dec 31, 1902 (Cubic Yards).	Remaining to be done Dec. 31, 1902 (Cubic Yards).
Earth excavation,	1,641,100	248,950	660,910	909,860	731,240
Rock excavation,	55,270	6,020	20,700	26,720	28,550
Tunnel excavation,	62,700	7,780	46,120	53,900	8,800
Natural cement concrete,	77,890	16,160	35,712	51,872	26,018
Portland cement concrete,	75,820	9,652	31,983	41,635	34,185
Brick masonry,	15,970	3,217	7,103	10,320	5,650
Ashlar and dimension masonry,	606	8	237	245	361

The following materials have been used during the year: —

Natural cement (barrels),	55,027
Portland cement (barrels),	45,613
Bricks,	3,739,000

Sanitary Inspection.

In May, two physicians, Dr. L. M. Palmer of South Framingham and Dr. Horace B. Frost of Weston, were appointed as medical inspectors. Dr. Palmer was assigned to the portion of the line west of the Sudbury River, and Dr. Frost to the portion east of the Sudbury River. They inspected the contractors' camps once a week, and as a result of their visits there was a considerable sanitary improvement at all of the camps.

Engineering.

The greater part of the time of the engineering assistants has been spent in the field, directing and supervising the work under construction. There has been, however, a small office force at the Saxonville office to attend to the drafting and other office work of the department. Some preliminary engineering work was required to prepare for the laying of the steel pipe lines and the blow-off from the steel pipe at Section 9. It has been necessary to make many detailed plans in connection with the construction of the work, also plans for the modification of highway crossings in Wayland. Considerable work has also been done in the preparation of record plans. The testing of cement has continued to be an important part of the work of this department, and has been in progress throughout the year. The force employed for this work has consisted of two cement testers and a third man for collecting samples; in addition, for several months during the busiest portion of the season a fourth man was stationed at the cement works in Binnewater, N. Y., to sample cement in advance of shipment, thus causing less delay for testing cement after it arrived at the work, and to some extent preventing the shipment of unacceptable cement to the work. During the year 692 carloads of cement, containing 102,350 barrels, were received and tested, and about 27,000 briquettes were made for this purpose. Four brands of Portland and two of natural cement have been furnished by the contractors and used during the year. A summary of all cement tests made upon the aqueduct to the end of the year is given in Appendix No. 2.

DISTRIBUTION DEPARTMENT.

DEXTER BRACKETT, *Department Engineer.*

The work of this department comprises the construction, maintenance and operation of the pipes, distributing reservoirs, pumping stations and all other works in the Metropolitan Water District, with the exception of Chestnut Hill Reservoir and the grounds about it, and the Sudbury and Cochituate aqueducts.

During the past year the work of the department has been under the direct charge of the following assistants: —

William E. Foss, division engineer, has had charge of the engineering work connected with the construction of Bear Hill Reservoir, and of the laying of 48-inch and 60-inch pipes from the terminal chamber of the Weston Aqueduct through Weston, Newton and Brighton. He has also been in charge of investigations relating to the electrolysis of water pipes.

John L. Howard, division engineer, has had charge of the engineering work in connection with the laying of 48-inch and 60-inch pipes in Medford, and until July 9 was in charge of the laying of 48-inch pipes in Brighton, near the Chestnut Hill Reservoir. He has also made surveys and investigations in relation to the improvement of Spot Pond Brook, and has done the engineering work in connection with raising the 36-inch pipes in Somerville at the crossing of the Mystic River.

Caleb M. Saville, division engineer, has had charge of the engineering work in connection with the Forbes Hill water tower, and the laying of 1.7 miles of 12-inch pipe in Hyde Park for supplying the high-service district in the town of Milton. He has also been in charge of studies relating to the use and waste of water in the Metropolitan District, and to the installation of Venturi meters.

Alfred O. Doane, division engineer, has continued in charge of the engineering work connected with the maintenance and operation of the pumping stations and pipe lines.

John W. Lynch, engineer of pumping stations, has continued in direct charge of the pumping stations at Chestnut Hill, and has had general supervision of the mechanical work at the other stations.

George E. Wilde, assistant superintendent, has had charge of the maintenance and operation of the pipe lines, reservoirs and other works in the Distribution Department, with the exception of the

pumping stations. The force employed under his direction, in addition to the ordinary maintenance work, set 24 Venturi meters, relaid 1,135 feet of 16-inch pipe in Revere, and raised 520 feet of 36-inch pipe at the crossing of the Mystic River.

Frank E. Fuller, an engineer employed for four years as assistant to Mr. Doane, was granted leave of absence in December, 1901, in order that he might take a sea voyage for the benefit of his health. The voyage did not prove of benefit, and he died at Santa Cruz on the island of Teneriffe on August 1. He was a very faithful and able assistant.

The engineering force, including inspectors, numbered 23 at the beginning of the year, was gradually increased to 38 during the summer, and at the close of the year numbered 30.

During the year the Bear Hill Reservoir and the water tower at Forbes Hill in Quincy have been completed. There have been laid 3.06 miles of 48-inch and 60-inch pipes, completing the second pipe line between Chestnut Hill pumping station and Spot Pond; 5.45 miles of 48-inch and 60-inch pipes, as a portion of a line connecting the new Weston Aqueduct with existing pipes near Chestnut Hill Reservoir, and 1.7 miles of 12-inch pipes for the purpose of supplying water to the high-service district of Milton. Twenty-four Venturi meters have been set on the connections through which water is supplied to several of the cities and towns in the District.

Pipes, Special Castings and Valves.

The following table gives the number of tons of pipes and special castings purchased during the year: —

	Diameter of Pipes (in Inches).							Special Castings.
	60	48	16	12	10	8	4	
United States Cast Iron Pipe and Foundry Company.	4,837.16	13,266.69	11.20	530.61	8.18	7.79	7.42	265.74
Camden Iron Works, . . .	-	-	42.88	-	-	-	-	342.12
Warren Foundry and Machine Company.	-	-	-	-	-	-	-	58.03
Taunton Locomotive Manufacturing Company.	-	-	-	-	-	-	-	36.06
The George F. Blake Manufacturing Company.	-	-	-	-	-	-	-	224.03
Davis & Farnum Manufacturing Company.	-	-	-	-	-	-	-	21.83
	4,837.16	13,266.69	54.08	530.61	8.18	7.79	7.42	947.81

Total, 18,711.93 tons pipe; 947.81 tons special castings.

Of the above, about 1,018.83 tons of pipes and 407.76 tons of special castings were used in connection with the work of the Wachusett Dam and Reservoir and Weston Aqueduct.

Valves have been purchased during the year as follows: —

	Size of Valves (in Inches).										Total.
	48	36	30	24	16	12	10	8	6	4	
Chapman Valve Manufacturing Company,	8	-	-	8	-	-	9	12	-	5	42
Coffin Valve Company,	2*	-	2*	-	26	43	2	2	1	8	86
The George F. Blake Manufacturing Company,	-	10	-	8	6	15	-	-	-	-	39
	10	10	2	16	32	58	11	14	1	13	167

* Sluice gates.

All of the 48-inch, 30-inch and 24-inch valves and sluice gates, together with a few of the smaller valves, were used at the Wachusett Dam or in connection with the Weston Aqueduct.

All pipes, castings and valves have been carefully inspected at the several places of manufacture.

For the convenient delivery of pipes to be used on the new pipe line from the Weston Aqueduct, a yard for receiving, storing and delivering pipes was established and is still in use near the Woodland station on the circuit branch of the Boston & Albany Railroad, on land belonging to the railroad company.

Pipe Laying.

During the year 10.6 miles of pipes have been laid, making a total of 82.09 miles now owned and operated by the Board in connection with the Distribution System.

Nearly all of the pipe laying has been done under the following contracts made during the year: —

CONTRACTOR.	Work and Location.	Date of Contract.	Value of Work done December 31.
C. E Trumbull & Co.,	Section 12, low-service pipe line, Medford,	April 3,	$44,431 59
Coleman Bros.,	Section 12, low-service pipe line, Medford,	May 2,	56,093 32
D. F. O'Connell,	Section 2, supply pipe line, Newton,	April 7,	70,100 00
T. F. Moore,	Section 4, supply pipe line, Brighton and Newton,	April 18,	26,600 00
Ward & Cummings,	Section 1, supply pipe line, Weston and Newton,	July 26,	24,300 00
T. Bruno,	Section 30, southern extra high-service pipe line, Hyde Park.	April 28,	7,602 81

Low-service Pipe Line, Section 12.

Under contracts made with C. E. Trumbull & Co. and Coleman Brothers, the 48-inch pipe line laid in 1897 from the Chestnut Hill pumping station to the old Boston Water Works mains near Tufts College in Medford has been extended to Spot Pond, so that there are now two large mains between Spot Pond and the District.

C. E. Trumbull & Co. laid 10,088 feet of 48-inch pipes between the end of the old main near Tufts College, through College Avenue, Summer and Walnut streets to South Street Court, and through Governors Avenue and other private property and the Middlesex Fells Reservation to a point not far from the junction of Forest Street, Fellsway West and the Border Road. Through South Street Court and across the Mystic River, for a distance of 439 feet, the pipes were laid in 1897. Work on this contract was commenced April 14. On July 3 pipe laying south of the Mystic River was finished, and on September 30 that north of the river. The pipes were carried over the Boston & Maine Railroad at College Avenue on a pipe bridge built in 1898, when the 20-inch pipe line was laid for supplying the high-service district in Somerville and Medford. At the time when plans were made and the contract was let for laying the 48-inch pipes, plans for laying out an extension of Governors Avenue as a public street were under consideration by the city government of Medford. The location of the proposed pipe line was through this extension of the street, and the line and grade of the pipes were fixed with reference to the proposed line of the new street, with the expectation that the street would be laid out before the work of pipe laying began. Action of the city government of Medford was delayed; and, in order that the contractor might proceed with his work, a taking was made on June 24 of the right to lay the pipes in a strip of land 20 feet wide. The street was laid out by the city government on July 17, and the surplus material from the pipe trench has been left on the ground for use in constructing the new street. In order to secure room for laying the 48-inch pipe, it was found necessary to relay 600 feet of 4-inch water pipe in Walnut Street, belonging to the Medford Water Department, and about 1,100 feet of 4-inch gas pipe in College Avenue and George Street.

Between the terminus of the pipe line laid by C. E. Trumbull &

60-INCH PIPE LINE THROUGH ROCK TRENCH IN MEDFORD.

Co. and the southern gate-house at Spot Pond, Coleman Brothers have laid a line of 60-inch pipes 6,084 feet in length. For a distance of 1,500 feet from the connection with the 48-inch pipes this pipe line is laid in a northeasterly direction through the Middlesex Fells. It then passes through Forest Street for 500 feet to its junction with Elm Street, then through the property of the city of Medford, passing under the easterly end of the dam at Wright's Pond and through the pond, which was emptied to facilitate the work, and then through the property of the Commonwealth to a point about 200 feet south of the gate-house at Spot Pond, where it connects with pipes previously laid. The pipes laid in Wright's Pond are covered for a distance of 1,500 feet by an embankment protected with a facing of stone, the top of which will be 5 feet below the surface of the water when the pond is full. Between Wright's Pond and the end of pipes previously laid near the gate-house at Spot Pond the trench was very largely in rock, and for a considerable part of the distance was from 15 to 32 feet in depth. In order to provide for the laying of a second line of pipe in the future, the trench, where excavated in rock, has been made 16 feet wide. The total amount of rock excavation was about 9,750 cubic yards. The completion of the work has been delayed by unfavorable weather, and on January 1 lacked four days of completion, but the whole length of the line has been included in the mileage for the year 1902. The work is completed, with the exception of filling over the pipes and sloping and loaming the sides of the trench through the deep cutting near Spot Pond.

In excavating the trench through the dam at Wright's Pond it was discovered that the concrete corewall of the dam had not been carried down to the rock when the dam was built. Two lines of pipe were laid through the dam, and after they were in position the corewall was rebuilt and carried down to solid rock for the full width of the trench. The corewall was also reinforced on each side, making it 6 feet in thickness, and the trench was filled with concrete to the centre of the 60-inch pipes for a distance of 25 feet each side of the corewall.

Supply Pipe Lines.

The work of laying the first of several pipe lines which will ultimately be required for conveying water from the terminus of the Weston Aqueduct into the Metropolitan District has been in progress

during the past year. A contract for the first section of the work, beginning at the terminal chamber of the aqueduct, was made with Ward & Cummings of Boston, on July 26. The work includes a single line of 60-inch cast-iron pipe 1,570 feet in length, extending from the terminal chamber in Weston, through land of the Commonwealth and through private property to the westerly shore of the Charles River, and three lines of 60-inch pipes crossing under the bed of the river for a distance of 350 feet. Two of these lines across the river are for future use; the third, which is connected with the line from the terminal chamber, will eventually supply two lines of 48-inch pipes, but for the present only one line is to be laid. Work under this contract was begun August 5. For laying the three lines of pipes under the Charles River the contractor was required to build a coffer-dam in two sections, so that there should always be nearly one-half of the river channel unobstructed. Work upon the western section of the coffer-dam, extending from the westerly shore of the river to the centre of the channel, enclosing a rectangular area 210 feet long by 50 feet wide, was begun August 15. The dam was constructed of two parallel rows of 4-inch tongued and grooved sheet piling, spaced 5 feet apart and driven to a maximum depth of 5 feet below the gravel bed of the river. The space between the two rows of sheeting was filled with a mixture of mud and gravel. The sheet piling was supported by round spruce piles driven 7½ feet apart on centres, and additional piles were driven inside the coffer-dam, which were used to support the bracing across the dam and also to support the sheeting of the trench, which was excavated inside the dam 25 feet in width and from 7 to 14 feet in depth. The bottom of this trench was about 14 feet below the average elevation of the water in the river. The material excavated was a rather coarse gravel, with coarse sand at the end of the excavation near the centre of the river. Through this the water flowed quite freely, and one 6-inch, one 8-inch and one 10-inch centrifugal pump were required to keep the water under control so that the pipes could be laid. The quantity pumped was estimated to be from 5,000,000 to 6,000,000 gallons per twenty-four hours. The excavation inside the dam was begun on September 30, but on account of the breaking down of the pumps and engines, and of the insufficient size of the pumping plant first installed, the work was delayed so that pipe laying was not begun until November 17. The joints

60-INCH PIPE LINES UNDER CHARLES RIVER IN WESTON AND NEWTON.

of the pipes were run solid with lead so that they could be calked on the inside as well as on the outside of the pipe. After the joints had been calked the pipes were embedded in Portland cement concrete, both for the purpose of preventing them from floating when empty and to protect them. The concrete was mixed in the proportion of 1 part by measure of cement, 3 parts of sand and 7 parts of stone, and the least thickness of concrete on the outside of the pipes is 6 inches. At the close of the year pipe laying between the terminal chamber and the centre of the river was completed, the westerly half of the coffer-dam pulled up, and about one-half of the round piles for the easterly half of the dam had been driven. In connection with this contract a gravel road 16 feet wide and 1,250 feet long has been built as a means of access to the terminal chamber from Loring Street.

The second section of this pipe line is 48 inches in diameter, and extends for 17,100 feet through the Commonwealth Avenue boulevard in Newton, from the easterly side of the Charles River to Walnut Street. A contract for doing the work was made with D. F. O'Connell of Boston, on April 2. The delivery of pipes along the line of the work was begun on April 26, and the excavation of the trench on April 29. The work was continued until the end of the year, and the last pipe was laid on December 30. The greatest number of men employed during any week was 221, and the average was 138. In order to provide room for the 48-inch pipes, or to provide for the surface drainage system in Newton, it was found necessary to lay 3,294 feet of vitrified pipe from 8 inches to 20 inches in diameter, to build 514 feet of 36-inch concrete drain, and to raise or lower water pipes at several points. Where the trench was excavated in rock it was made 14 feet in width, so that blasting alongside the pipes will not be necessary when another parallel line is laid in the future. At the crossing of the Boston & Albany Railroad a right of way was taken through land belonging to the railroad company and the city of Newton, in which the pipes were laid crossing under the four tracks of the railroad alongside the bridge.

The work of replacing the Telford foundation and resurfacing the roadways on this section has been done by the Street Department of the city of Newton, at the expense of the Commonwealth. At the close of the season 12,100 linear feet of the roadway had been resurfaced, leaving 4,700 linear feet to be done to complete the work.

The cost of work done under this contract has been about 40 per cent. more than the estimated amount, due to changes made in the plans in order to avoid interference with the surface drainage system of the city of Newton, and to finding much more rock than was expected.

No contract has yet been made for the third section of this pipe line, which is about 9,800 feet in length, and will connect the end of Section 2 at the corner of Commonwealth Avenue and Walnut Street with Section 4 on Kenrick Street, near Waverley Avenue.

That part of the pipe line known as Section 4 begins on Kenrick Street near Waverley Avenue, and extends through Magnolia Avenue and through private property to the Cochituate Aqueduct lands, which it enters at a point not far from the ventilator chamber on the aqueduct; thence it extends parallel with and from 12 to 15 feet north of the aqueduct for a distance of 3,100 feet to Commonwealth Avenue, which it enters near the line between Newton and Brighton; thence in the southerly roadway of Commonwealth Avenue to the easterly end of Chestnut Hill Reservoir, and along the side of the reservoir for a distance of 900 feet to a point near the old effluent gate-house, where it will be connected with two 48-inch mains leading toward Boston. A side outlet into Chestnut Hill Reservoir is also provided.

A contract for laying these pipes was made with Thomas F. Moore of Syracuse, N. Y., on April 18, 1902. This contractor used a travelling machine for handling both the excavated material and the pipes, which was convenient and economical, but the rate of progress was slower than by the usual methods of pipe laying. The machine consisted of a carriage spanning the trench, with wheels at the bottom running on rails laid on each side of the trench. By means of an engine and boiler mounted upon a platform at the forward end of the excavation, and wire ropes attached to the carriage and passing around a pulley fastened to a fixed support at the rear end of the trench, the excavated material was raised, transported and deposited in the trench after the pipes were laid, and the pipes themselves were also transported, lowered into the trench and placed in position by the machine. The average rate of progress when no unusual conditions were encountered was from 350 to 400 feet per week. At the end of the year the pipes were all laid with the exception of 100 linear feet on Kenrick Street. The trench

has not been resurfaced for a distance of 3,500 feet at the westerly end of the section, and the work cannot be entirely finished until the coming spring.

Southern Extra High-service Pipe Lines, Section 30.

On April 28 a contract was made with T. Bruno of Boston for laying 8,800 feet of 12-inch pipe in Hyde Park, through West Street, from the West Roxbury line to the Neponset River, across the Neponset River and through Metropolitan Avenue to the Milton line, for the purpose of connecting the pipe system in West Roxbury with that in Milton, in order that the higher portions of Milton might be supplied from the pumping station and standpipe of the West Roxbury high service. The work was commenced May 5 and completed August 22. At the crossing of West Street over the New York, New Haven & Hartford Railroad the pipes were placed under the floor of the sidewalk, and protected from the cold and from the locomotive gases by a covering made by steel plates placed underneath the pipe and riveted to the sidewalk stringers, which, with the stringers and sidewalk planking, make a comparatively tight box. The Neponset River, at the point where the pipe crosses, is about 140 feet in width, with a maximum depth of 6½ feet. The pipes used for crossing the river were made with ball and socket joints. The contractor attempted to excavate the trench across the river and lay the pipes by the use of a coffer-dam, but finally abandoned this method, and excavated the trench with a dredge. The pipes were then joined together on the westerly shore, buoyed by empty oil barrels and drawn across the river, after which the barrel lashings were cut, allowing the pipe to settle into the trench.

Bear Hill Reservoir.

The C. H. Eglee Company had completed the greater part of the work of constructing this reservoir at the close of the year 1901, and during the winter it was kept filled with water to within 3½ feet of high-water mark, in order to protect the masonry. On April 3 the water was drawn off, and on April 17 work was resumed. The reservoir basin was completed on June 18, and filled with water on June 21 and 22. The construction of walks, grading of embankments and cleaning up of the grounds were finished on July 8.

The reservoir is 15 feet in depth, has a capacity of 2,450,000 gallons, and the high-water elevation is 300 feet above Boston City Base. It was formed by constructing two dams across a depression in the rocky ridge which forms the summit of Bear Hill, and enclosing an area of about three-fourths of an acre. From this area the earth and rock were excavated for constructing the dams; the rock surface, which composes nearly the entire bottom and slopes of the reservoir, was very thoroughly cleaned; the seams, which were very numerous, were carefully pointed with Portland cement; and the entire surface of the rock washed with Portland cement grout. The dams were built with an inner wall of Portland cement concrete, supported on the outer side by an embankment of earth and loose rock. The concrete wall is vertical from the bottom to elevation 295, or 5 feet below high-water mark, and above that point slopes outward and upward, with an inclination of 1 horizontal to 1 vertical, to a level 2 feet above high-water mark. The upper 5 feet of the slope are paved with stones from the excavation, averaging 16 inches in depth, laid in cement mortar.

A small gate-chamber, built of concrete masonry with exterior granite facing, is located near the centre of the north dam. This chamber contains sluice gates for controlling the flow into and out of the reservoir, and a waste gate for draining the reservoir. In addition to a 20-inch pipe which enters the gate-chamber from the north, and acts both as a supply and delivery pipe, a 20-inch pipe has been laid from the chamber across the bottom of the reservoir, and carried through the south dam for use in supplying other towns in the future. The superstructure of the gate-chamber has not yet been built.

The cost of the reservoir, exclusive of engineering, to December 31, 1902, was $28,411.40. The capacity of the reservoir was increased nearly one-fourth above the original estimate, owing to the fact that the ledge composing the reservoir site was found to be very much broken up and full of seams, necessitating the removal of more rock than was expected; and the cost of the reservoir was also increased, both by the cost of removing the rock and because of the pointing of seams, — a work which required much time and careful attention.

Forbes Hill Water Tower.

At the close of the year 1901, James E. McCoy, the contractor for the construction of this tower, had built the circular masonry wall encircling the standpipe to a height of about 70 feet, or 7 feet below the finished height. The work progressed slowly, and was not completed until July 19. The tower is 77 feet high from the surface of the ground to the tops of the merlons. It is circular in section, having an inside diameter of 36½ feet, leaving a space of 3.25 feet between the wall and the outside of the standpipe which it encloses. The wall is built of uncoursed masonry, with joints of about ¾ of an inch, and with cut-stone trimmings; and is 4.75 feet thick at the base and 2 feet thick at the top just below the cornice. The granite used for the masonry was all furnished from the Quincy quarries, and the cut stone from both Quincy and Rockport. At the top of the tower there is a granolithic roof, which is accessible to the public by means of an iron stairway encircling the standpipe. This roof or floor is 260 feet above Boston City Base, and affords an extended view of the surrounding country.

The total cost of the tower, exclusive of engineering, was $26,120.

Installation of Venturi Meters.

On May 13, 1902, an act of the Legislature was approved, authorizing the construction of works for measuring the water supplied to each of the cities and towns in the Metropolitan Water District; and for the purpose of carrying out the provisions of this act a contract was made on June 20 with the Builders Iron Foundry of Providence, R. I., for furnishing 42 Venturi meters, in sizes from 8 inches to 48 inches; and on August 4 a contract was made with the Daniel Russell Boiler Works of South Boston for furnishing 36 steel chambers in which to place the registering apparatus of the meters. When the contract for the meters was made, it was expected that they would all be delivered in time to be set before the end of the working season; but, on account of difficulties in obtaining castings, and for other reasons, the work has been delayed, and only 24 of the meters were received in season to be set before the work was stopped by the cold weather; and none of the registers had been received on December 31, although a few had been shipped by the manufacturer.

At the close of the year the meter tubes and the chambers for holding the registering apparatus had been set at the following points: —

City, Town or District.	Location.	Size of Meter (Inches).
Arlington, . . .	Medford Street, at Parallel Street, ...	20
Belmont, ...	Common Street, at Belmont Street, ...	12
East Boston, . . .	Condor Street, at Brooks Street, ...	24
Charlestown, . . .	Broadway, at Walnut Street, Somerville, ...	24
Brighton, ...	Chestnut Hill Avenue, at Beacon Street, ...	16
Chelsea, ...	Powderhorn Hill, near Reservoir, ...	16
Everett, ...	Hancock Street, at Broadway, ...	16
Everett, ...	Broadway, at Corey Street, ...	20
Malden, ...	Highland Avenue, at Clifton Street, ...	16
Malden, ...	Clifton Street, at Washington Street, ...	16
Malden, ...	Medford Street, at Pearl Street,.	12
Medford, ...	High Street, near Governors Avenue, ...	10
Medford, ...	Boston Avenue, at College Avenue, ...	8
Medford, ...	Governors Avenue, at High Street, ...	20
Medford, ...	Jerome Street, at High Street, ...	10
Melrose, ...	Ravine Road, at way to Melrose Reservoir, . . .	20
Milton, ...	Adams Street, at Canton Avenue, ...	12
Revere, ...	Prospect Avenue, near Revere Reservoir, ...	12
Somerville, . . .	Boston Avenue, at Professors Row, ...	12
Somerville, . . .	Broadway, at Willow Avenue, ...	16
Somerville, . . .	Broadway, at Marshall Street, ...	12
Somerville, . . .	Webster Avenue, near Newton Street, ...	20
Watertown, . . .	Mt. Auburn Street, near Irving Street, ...	16
Winthrop, . . .	Atlantic Avenue, at Crescent Avenue, ...	16

The Venturi meters consist of two truncated cones joined at their smallest diameters by a short throat piece having a diameter varying in different meters from ¼ to ½ of the diameter of the large ends of the cones, the three parts making what is known as the meter tube. At the up-stream end and at the throat small holes are drilled into the tube, from which pipes are carried to the register. The operation of the meter is due to the fact that when water is flowing through the tube the pressure at the throat is less than at the up-stream end of the tube, and that the difference in pressure is

dependent upon the quantity of water flowing through the tube. The differing pressures at the up-stream end and throat of the meter are transmitted through small pipes to the register, which can be located at any convenient point within 300 or 400 feet of the tube. In the register the differences of pressure affect the level of a column of mercury which carries a float. The position of this float is thus made dependent upon the quantity of water passing through the meter, and by suitable mechanism the quantity is recorded by a counter, and the rate of flow at intervals of ten minutes is continuously recorded upon a roll of paper, so that the fluctuations in the flow during different hours of the day can be observed. Although the pressure at the throat of the meter is often several pounds less than at the inlet or up-stream end, the lost pressure is nearly all regained by the time the water reaches the outlet end of the tube, so that the net loss of pressure caused by the meter is seldom more than one pound under ordinary circumstances.

The entire consumption of the principal low-service district of Boston, amounting to 40,000,000 gallons per day, has for the last two years passed through two 48-inch meters of this type.

Miscellaneous.

Apparatus for operating the hydraulic sluice gates at the southern gate-house at Spot Pond, consisting of a force pump operated by hand, the necessary piping between the pump and the cylinders, and a tank for storing surplus oil, was installed in February, the work being done by the maintenance force. Oil which will not congeal at 1° below zero, F., was used in the cylinders for operating the valves.

On November 14 an additional connection 12 inches in diameter was made between the Metropolitan mains and the Watertown pipe system at the junction of Common and Orchard streets in Watertown.

Engineering.

The engineering force has been engaged upon the preparation of plans and contracts, and the superintendence of the construction of 10.6 miles of pipes, generally 48 inches and 60 inches in diameter, of the water tower at Quincy, and of the Bear Hill Reservoir in Stoneham. Surveys and plans have been made of Spot Pond Brook for a distance of nearly 4 miles between Spot Pond in Stoneham

and Centre Street in Malden, and studies and plans have been made for the improvement of the brook. The results of these surveys and investigations have been embodied in a special report for presentation to the Legislature.

Investigations and plans have been made for metering the water supplied to the several cities and towns, and investigations have been commenced to determine the quantity of water used and wasted throughout the District.

In connection with the maintenance of the works, the engineering force has superintended the installation of a new boiler at the Arlington pumping station, made tests of oils and coal in use at the pumping stations, prepared plans for additional steam piping at the low-service station at Chestnut Hill, and kept records of pressures in water mains, quantity of water pumped and consumed, and the elevation of the water in the several reservoirs.

OFFICE FORCE.

ALFRED D. FLINN and FRANK T. DANIELS, *Principal Office Assistants*, JOHN N. FERGUSON, *Office Assistant.*

As already stated, Mr. Flinn resigned to accept a position elsewhere, the resignation taking effect October 6; and Mr. Frank T. Daniels, who occupied the position of division engineer in charge of the drafting department of the Metropolitan Sewerage Works, was transferred to the Water Works to take the vacant position.

The average number in the drafting force during the year was 10, the same as last year.

The most important matters upon which the force has been engaged were the Wachusett Dam, the Weston Aqueduct, the relocation of the Central Massachusetts Railroad, the highway bridges at crossings of the Wachusett Reservoir, and the preparation of some of the contract plans for Section 10 of the Wachusett Reservoir, involving, among other things, an enlarged channel for the Quinepoxet River and a small circular concrete dam across the river.

In connection with the work in progress at the Wachusett Dam many working plans have been made, particularly of the upper and lower gate-chambers, and the valves, pipes and other castings to be built into these structures and the dam. Before the final drawings could be made for the lower gate-chamber, which is to form the foundation for the power house, it was necessary to complete the

preliminary studies for the power plant and the preliminary drawings for the superstructure. The latter drawings were made by Messrs. Shepley, Rutan & Coolidge, architects. Much time of the department has been consumed in following up orders for pipes, valves, special castings and steel work, to prevent delay in the construction of the dam.

The designing for the Weston Aqueduct related principally to the various chambers, the siphons across the valleys and the headworks near the Sudbury Dam. Plans have also been made showing the necessary dimensions of ten superstructures required in connection with the aqueduct, which have since been designed by Messrs. Shepley, Rutan & Coolidge. Contracts and specifications for seven of these structures have been prepared in part by the drafting department. In addition to the office work, Mr. Flinn had charge of the manufacture and inspection of the 7½-foot riveted steel pipes for the siphons of the aqueduct. Drawings and specifications were prepared for the connections between the pipes through the Sudbury Dam and the head-chamber of the aqueduct. These connections included some difficult work in large pipes and special castings, a large underground outlet chamber through which water can be discharged into the channel leading to Framingham Reservoir No. 3, a masonry arch bridge of 30-foot span, a head-chamber and two smaller chambers, together with extensive grading.

For the relocation of the Central Massachusetts Railroad, designs were prepared for the tunnel through the hill near Boylston Street, including two masonry portals, for the abutments of two highway bridges, for abutments and pedestals for the viaduct across the valley of the Nashua River, for masonry arch bridges to carry Clamshell Road over the railroad and the railroad over the waste channel below the dam, and for other minor structures. In this work the department conferred with Mr. J. P. Snow, the bridge engineer of the Boston & Maine Railroad, who also furnished the specifications and contract drawings for the steel superstructures of the two plate-girder bridges and the viaduct.

In addition to the larger work already indicated, the drafting department has been engaged on many detailed and minor drawings, and has made a large number of record plans. Among the minor drawings may be mentioned the plans for a frame carpenter shop to take the place of one burned at Chestnut Hill Reservoir, a design

for steel chambers for the registers of Venturi meters to be placed beneath the sidewalks, a design of somewhat difficult centering for a skew arch bridge over the waste channel at the Wachusett Dam, and plans of the foundation and superstructure of a brick pumping station to be built at the Pegan Brook filters in Natick.

In all, 177 finished drawings were made during the year, also many studies, sketches and computations.

Mr. Ferguson has continued in charge of the miscellaneous work of the office, such as receiving applications from those desiring employment, procuring supplies, making blue-prints and filing plans and records received from outside offices. He has furnished much assistance to the Conveyancing Department in the preparation of land plans, has made many investigations and computations, and has done much other work of so varied a character that it cannot be enumerated in a report. The average force in his department has numbered 7.

Accidents.

Six fatal accidents have occurred during the year, 1 at the Wachusett Dam, 2 at the quarry which furnishes stone for the dam, 1 on the relocation of the Central Massachusetts Railroad and 2 on the Weston Aqueduct.

All of those at the Wachusett Dam, quarry and relocation of the railroad occurred in connection with the work of the McArthur Brothers Company. At the dam a laborer was killed by falling with a car from a trestle 20 feet high; at the quarry one laborer was killed by the falling of one of the weights from the tripod of an air drill which was being moved by a derrick, and another by the falling of a large stone which was being removed by a derrick; on the relocation of the railroad a foreman was killed by a premature blast.

The first accident on the Weston Aqueduct occurred on Section 13, where a laborer was killed by a runaway car on an incline; and the second on Section 14, where a laborer was caught under a car while dumping it.

MAINTENANCE.

The additional works maintained and operated in 1902 are the Bear Hill Reservoir in Stoneham and a new pipe line in Hyde Park to supply water to the high portions of Milton.

Organization of Maintenance Force.

At the beginning and end of 1902 the total maintenance force employed directly by the Board was 174, exclusive of such of the engineers as devoted only a part of their time to maintenance. From time to time during the year there has been an additional temporary force engaged on special work, making the maximum number, including both the permanent and temporary force, 233.

Rainfall and Yield.

The total rainfall for the year has been a very little less, and the yield of the watersheds a very little more, than the average. The distribution of the rainfall and yield throughout the year has not differed enough from normal to call for any special mention. Statistics relating to rainfall and yield of watersheds may be found in Appendix No. 3, tables Nos. 1 to 11.

Storage Reservoirs.

Early in January the reservoirs on the Sudbury and Cochituate watersheds were as nearly full as it is desirable to keep them during the winter months. At the beginning of May they were entirely filled, and remained so until the first day of June, when they contained 16,129,500,000 gallons of water; after which the quantity of water stored gradually decreased until September 30, when there were 9,603,700,000 gallons in store. From this time until the middle of December the water in the reservoirs was rising slowly, and for the remainder of the year at a rapid rate.

The following table gives the quantity of water stored in the storage reservoirs at the beginning of each month. The second column gives the total in the reservoirs from which the supply is usually taken, the third column the storage in the other reservoirs, and the last column the total storage in all storage reservoirs.

Quantity of Water stored in Reservoirs on Sudbury and Cochituate Watersheds at the Beginning of Each Month.

DATE.	In Sudbury Reservoir and Framingham Reservoir No. 3 (Gallons).	In All Other Storage Reservoirs (Gallons).	Total (Gallons).
January 1, 1902,	7,127,200,000	6,712,900,000	13,840,100,000
February 1,	7,746,500,000	6,601,100,000	14,347,600,000
March 1,	7,754,400,000	6,869,600,000	14,624,000,000
April 1,	8,091,300,000	7,238,400,000	15,329,700,000
May 1,	8,489,600,000	7,503,400,000	15,993,000,000
June 1,	8,489,400,000	7,640,100,000	16,129,500,000
July 1,	7,776,400,000	7,459,700,000	15,236,100,000
August 1,	6,649,400,000	6,564,600,000	13,214,000,000
September 1,	5,972,000,000	5,536,100,000	11,508,100,000
October 1,	5,043,300,000	4,685,800,000	9,729,100,000
November 1,	5,643,900,000	4,568,100,000	10,212,000,000
December 1,	5,636,300,000	4,550,000,000	10,186,300,000
January 1, 1903,	6,236,600,000	5,479,500,000	11,716,100,000

NOTE. — The storage in Dudley Pond is included in this table.

Sudbury Reservoir. — From the beginning of the year until the latter part of March the water in the Sudbury Reservoir was a little below the level of the crest. It reached the crest on March 26 and the top of the flash-boards on April 9. The surface remained near high-water level until June 15, when the draft from the reservoir began to exceed the supply; it receded gradually about 8 feet, reaching elevation 251.85 on September 30. At the end of the year the water was 3.95 feet below the crest of the dam.

The Marlborough Brook filter-beds, at the head of one branch of the Sudbury Reservoir, have been in service throughout the year. They filtered all the water of the brook, excepting for short periods of less than a day each on several occasions during freshets. During the year it was found necessary, besides removing the film which had collected upon the surface of the beds, to take off about 2 inches of sand which had become filled with fine organic matter. A considerable quantity of small stones was also removed from the "natural" beds and placed on the outside of the banks. Studies for an apparatus for washing the sand upon the beds and tests of an experimental apparatus have been made during the year.

Analyses have been made monthly by the State Board of Health of the water before and after passing through the filter-beds, which show that the water was purified by the filters to a fairly satisfactory extent.

The walls of Marlborough Brook above the Walker Street culvert, which were in bad condition, have been taken down and rebuilt for a distance of about 150 feet. The concrete structures connected with the filter-beds, which had cracked during the winter, have received the necessary pointing.

A horse shed has been built near the filter-beds.

A large number of hemlock, white pine and white spruce trees has been set out, and other small improvements have been made around the Sudbury Reservoir.

While preparing for the connections with the Weston Aqueduct, it was discovered that the granite in the pipe-chambers and the bell-mouths connecting the chambers with the pipes through the dam had been badly eroded in places by the action of the water at high velocities. The erosion had proceeded to such an extent that the bell-mouths, which were of cast iron 1.25 inches thick, were worn entirely through at a few points. Repairs to two of the chambers and bell-mouths have been made by bolting steel plates over the eroded places.

Framingham Reservoir No. 3, which derives its supply almost wholly from the Sudbury Reservoir, was kept nearly full throughout the year, with an extreme range in elevation of about 4.5 feet. While the Sudbury Reservoir was full, or from early in April until the first part of June, the flash-boards were in position on the dam and the water kept as high as possible; but during the remainder of the year it was in general kept about 1 foot below the crest, to avoid wasting water from the effect of the wind.

Framingham Reservoir No. 2. — Water was drawn in considerable quantities from this source for the supply of the Metropolitan District between June 30 and November 20. The surface was kept within 2 or 3 feet of high-water level by drafts from Ashland, Hopkinton and Whitehall reservoirs. Except during the period mentioned, the reservoir has been full throughout the year.

The top planking of the Fountain Street bridge has been renewed, and Fountain Street gravelled within the limits of the reservoir, a distance of about 1,200 feet.

Framingham Reservoir No. 1 has been kept practically full throughout the year. Water was drawn in small quantities from this reservoir for the supply of the District from May 16 to June 29.

Ashland Reservoir. — At the beginning of the year water was flowing over the spillway, and except as drawn down during February and March in anticipation of freshets, the reservoir remained full until the first of August. After that date water was drawn into Framingham Reservoir No. 2 until October 27, when the surface was at elevation 213.98, or 11.23 feet below high water. The water then began to rise, and at the end of the year was 3.89 feet below high-water mark. All the joints on the exterior of the gate-house, in both brick and stone work, were pointed as far as they were accessible.

Hopkinton Reservoir. — Water in this reservoir was flowing over the spillway at the beginning of the year. Except during February and March, when it was drawn down in expectation of freshets, the reservoir remained full until July 3, after which water was drawn from it to maintain the level of Framingham Reservoir No. 2, and the surface gradually fell, reaching elevation 293.23, 11.77 feet below high-water mark, on October 1. At the end of the year it had risen to a point 2.12 feet below high water. All the water drawn from this reservoir for maintaining the supply was filtered through the filter-beds below the dam.

Whitehall Reservoir was practically full throughout the year, except during February, when it was drawn down somewhat in anticipation of freshets. But little water has been drawn from this source to maintain the supply, and that between September 18 and October 14.

Farm Pond was full during the early part of the year, but after the first of June was gradually drawn down to a point about 1 foot below high water by the operations of the Framingham Water Company. At the end of the year it had risen to 0.53 of a foot below high water. No water has been drawn from this pond for the supply of the Metropolitan District.

At the Farm Pond gate-house the joints in the stonework and part of the brickwork have been thoroughly pointed, and a cap has been put on the chimney.

Lake Cochituate at the beginning of the year was 2.71 feet below high water; it was full on March 2, and so remained until the latter

part of June. After this date the quantity drawn through the aqueduct was sufficient to lower the water at a practically uniform rate until November 21, when it was 8.76 feet below high-water mark. From this date to the end of the year the water was rising, and at the end of the year was 6.08 feet below high water.

Water was wasted at the outlet dam almost continuously from the beginning of the year to January 24, and from February 18 to May 15.

The diversion from the lake of the water collected on 1.96 square miles of Snake Brook watershed, in connection with the work of improving Snake Brook Meadow, as described in the last annual report, was continued until January 24. Allowance for this diversion and also for the amount of water pumped from Snake Brook Meadow and diverted from the lake was made in estimating the yield of the Cochituate watershed.

Excepting 100,000 gallons on April 2, no water was discharged from the Sudbury Aqueduct into the lake during the year.

Advantage was taken of the low stage of the water to excavate a considerable quantity of mud from the southerly end of the lake just west of the Boston & Albany Railroad culvert. An arrangement was made with Auguste Saucier, contractor for the work of excavation at Pegan Brook Meadow, to do this work, which was executed between the middle of October and December 4. The mud excavated was piled in embankments above high-water mark, and a considerable additional area of muddy bottom, which it was inexpedient to excavate, was covered with clean sand.

There were 51,400,000 gallons of water drawn from Dudley Pond into Lake Cochituate between September 4 and 13. At the beginning of the year the pond was 2.17 feet below high water and at the end of the year 3.69 feet below high water. The highest point was reached on April 14, when the surface was 0.44 of a foot below high water.

The Pegan Brook filter-beds in Natick have been in use 257 days during the year. All of the brook water was filtered except for portions of four days, when a small amount of water overflowed the settling reservoir and passed into the lake. Some of these filter-beds have also been used for filtering the water pumped from Pegan Brook Meadow while the work of excavation was in progress, and when the water was consequently unfit to be discharged into the

lake. The total quantity of water pumped from Pegan Brook during the year was 224,677,800 gallons. The total quantity of coal consumed was 253,770 pounds, making 885 gallons of water pumped per pound of coal.

The pumping plant now in use for raising water from the Pegan settling reservoir to the filter-beds consists of two 6-inch centrifugal pumps, belted to a semi-portable engine and boiler, and was originally installed in a rough wooden house as a temporary plant. Owing to the unsatisfactory character of this plant and to the decision, already noted, to extend the Pegan Brook filtration system while making the improvements at the Pegan Brook Meadow, it was concluded to entirely reconstruct the pumping plant upon a permanent basis. Plans have accordingly been made for a small brick pumping station, which it is intended to erect early in the coming year just below the dam of the old settling reservoir.

The foundations of the station have been carried to an average depth of about 9 feet through mud to a firm stratum of sand and fine gravel. A beginning was made in December, and about one-half of the concrete foundations was completed at the end of the year.

The machinery to be installed will consist of one 8-inch and one 10-inch centrifugal pump, directly connected to vertical compound engines of the marine type, similar to those in use at the Alewife Brook pumping station of the Metropolitan Sewerage Works.

A force main will be laid from the new pumping station, to connect with the existing pipe which discharges upon the filter-beds, and also with a 12-inch pipe under the Boston & Albany Railroad, which was laid at the time the new railroad embankment was constructed, by which the farther beds can be reached through a second pipe line. At the end of the year only a few lengths of this pipe had been laid.

Sources from which Water has been taken.

During the year the only water supplied from local sources was 20,190,000 gallons supplied for use in the town of Milton by the Hyde Park Water Company, and 9,830,000 gallons drawn by the city of Medford from Wright's Pond, making in all an average of 82,000 gallons per day for the whole year from local sources. All of the supply, except this very small quantity, was furnished by

the Metropolitan Works, which supplied an average of 107,186,000 gallons per day. An average of 66,127,000 gallons a day was drawn from the South Branch of the Nashua River through the Wachusett Aqueduct into the Sudbury Reservoir, and an average of 85,314,000 gallons a day was drawn through the Sudbury Aqueduct from Framingham Reservoir No. 3, which obtains its supply mainly from the Sudbury Reservoir. An average of 10,331,000 gallons per day was drawn through the Sudbury Aqueduct from Framingham reservoirs Nos. 1 and 2, which receive all of the water supplied by the main Sudbury River. An average of 12,165,000 gallons per day was drawn from Lake Cochituate.

The utmost care is taken to draw as little water as possible from the less satisfactory sources, and to draw the water only at such times as it is in good condition; but the maintenance of the supply, with the existing condition of the works and the large consumption of water, makes it necessary to draw some of the water from the less desirable sources.

Aqueducts.

The *Wachusett Aqueduct* has been in use 309 days during the year. It was shut off for 35 days in the winter and spring, when the river water was somewhat turbid, and on 21 days was shut off for cleaning the aqueduct, making repairs to the small flume near the dam, or for changing from the temporary to the permanent works at the dam. The usual work of maintenance along the line of the aqueduct has been performed, and the aqueduct and its appurtenances are in excellent condition.

The *Sudbury Aqueduct* was in constant service throughout the year, except on a few occasions when it was necessary to empty it for cleaning. The total flow for the whole year averaged 95,645,000 gallons per day, which is 5,317,000 gallons more than the daily amount of water carried by the aqueduct last year. The interior of the aqueduct from Framingham Dam No. 1 to the terminal chamber at Chestnut Hill Reservoir was cleaned twice during the year; first on April 3, 10, 17 and 24; and a second time on October 16, 23 and 30, and November 6. The siphon pipes were cleaned at the time of the first cleaning only. In April it was found that the interior of the aqueduct was covered with a thick coating of black slime for its entire length, and considerable quantities of sponge

were found, principally on the invert. At the time of the second cleaning the slime was not very thick, and but little sponge was found. The second cleaning was undertaken in order to maintain the capacity of the aqueduct at as high a figure as possible during the winter, when the consumption of the water in the District is greatest.

The Framingham low-level sewer in the valley of Beaver Dam Brook passes under the Sudbury Aqueduct at the junction of Irving and Herbert streets in South Framingham. The Framingham Sewer Department began the construction of this crossing on August 4. It was intended to employ the method of forcing cylindrical telescopic steel pipes from each side through the earth at some distance below the bottom of the aqueduct, in accordance with a plan which had proved successful in other cases. The work had progressed so that pits on both sides of the aqueduct had been carried down to grade, and one of the pipes was in position to be forced under the aqueduct, when it was found that the condition of the ground was such that the aqueduct was likely to be injured if the work proceeded in accordance with the plan. As it was necessary to keep the aqueduct running full without cessation in order to supply water to the District, no work which menaced the safety of the supply could be permitted, even though it might have proved successful. On the other hand, it was very desirable that the work should be completed without delay, in order to divert sewage from a somewhat thickly populated district, which was a menace to the purity of the water supply. Under these circumstances it was decided to adopt a different plan, which provided for removing the earth from over and around the aqueduct and for supporting the aqueduct from heavy steel beams crossing the sewer trench, also for making a passage for the sewer pipe immediately under the wooden platform on which the aqueduct was constructed. This additional work was done by the Board. The aqueduct was suspended from two 20-inch steel beams on either side of and parallel with it by steel rods having stirrups at their lower ends, which supported the ends of 8-inch steel beams passing under the platform on which the aqueduct was built. The nuts on these suspension rods were screwed up to such a point that the whole weight of the aqueduct was supported by the beams. The 18-inch cast-iron pipe was placed in position under the aqueduct, and all spaces under the platform and around the pipe and 8-inch beams

were entirely filled with Portland cement mortar. Work under the new plan was begun on September 15 and completed on November 12, at an expense of a little more than $3,000.

Boylston Street in Newton has been widened to accommodate the tracks of the Boston & Worcester Street Railway. Where the aqueduct passes under Boylston Street it has been strengthened by an additional ring of brick for a length of about 51 feet. While the widening was in progress the city of Newton placed two 8-inch pipes, one for sewage and the other for surface drainage, in the culvert under the aqueduct, in addition to an 8-inch water main previously laid there. After the new pipes had been placed the culvert was filled solid with natural cement concrete.

The interior of the arches at the Waban Bridge was heated with steam during the winter months, to prevent the formation of ice inside of the bridge. Echo Bridge also requires considerable attention during the cold weather, to prevent the formation of ice in the interior of the arches.

A storehouse 21 feet by 40 feet on the ground and one and one-half stories high has been built near the west siphon chamber. The entire exterior surface was covered with galvanized iron, as a protection against fire.

All the joints in the masonry of Beaver Dam Brook culvert and those in the up-stream side of the Course Brook culvert above water level were pointed during the year.

The *Cochituate Aqueduct* was in use 259 days. The interior of the aqueduct was cleaned from the influent gate-house at Lake Cochituate to Brookline Reservoir, with the exception of the siphon pipes, on May 1, 2 and 3. The interior coating of black slime was thick near the westerly end, but gradually diminished in thickness from Dedman's waste-weir to the intermediate gate-house at Chestnut Hill Reservoir, except at the westerly end of the Newton tunnel, where there was a thick coating. Sponge was found in considerable quantities, especially where the slime was thick. From the intermediate gate-house to the Brookline Reservoir, especially in the Brookline tunnel, the coating was very thick, with considerable quantities of sponge.

In May, by permission of the Boston Water Commissioner, a stop-plank gate was built in Webber's waste-weir, a short distance east of the Chestnut Hill pumping station, by which the Cochituate

Aqueduct could be shut off at that point and the Brookline Reservoir disconnected.

A new flume was put in the embankment over the aqueduct in the cut east of Snake Brook, by which any diversion of water from the Cochituate watershed at this point can be controlled.

The masonry of the substructure of the east pipe chamber at the Charles River siphon was strengthened many years ago by a casing of concrete. It was discovered that this concrete had settled away from the masonry and cracked. All the spaces and cracks were cleaned out, grouted and pointed with Portland cement. The iron-work in all structures along the aqueduct has been painted. The aqueduct was crossed at five places in Wellesley by the mains of the Newton & Watertown Gas Company. At these crossings, and for some distance on each side of the aqueduct, the gas pipes were laid with lead joints.

The quantity of water flowing in both the Sudbury and Cochituate aqueducts has been determined by current meter measurements made from time to time during the year.

Pumping Stations.

All water supplied to the Metropolitan Water District has been pumped at the two stations at Chestnut Hill Reservoir, with the exception of the very small quantity of water supplied from the Spot Pond watershed and by cities and towns from local sources. Seventy-two per cent. of the water was pumped at the low-service and 28 per cent. at the high-service station. The supply for the northern high-service district, after being pumped from Chestnut Hill to Spot Pond, has been again raised to the Fells or Bear Hill reservoir. The supplies for the northern extra high service in Arlington and the southern extra high service in West Roxbury and Milton have been pumped at the small stations in Arlington and West Roxbury.

The daily pumping capacity of all the stations is 204,500,000 gallons, and the force employed numbers 48, both figures being the same as at the date of the last annual report.

The total quantity pumped at all of the stations during the year was 42,000,400,000 gallons, and the cost of operating the stations was $105,226.76, equivalent to $2.50 per million gallons pumped. This is 2 cents less than the corresponding cost for the year 1901, and

may be considered a favorable showing, taking into consideration the facts that the cost of fuel, which is nearly one-half of the total expense of pumping, was from $0.50 to $0.85 per ton, or 12 to 20 per cent. more in 1902 than in 1901, and that a large payment on account of new boilers made the cost of repairs 12 cents more per million gallons pumped than for the previous years.

Coal for use at the several stations has been purchased as follows: —

	Gross Tons.					Price per Gross Ton.
	Chestnut Hill High-service Station.	Chestnut Hill Low-service Station.	Spot Pond Station.	West Roxbury Station.	Arlington Station.	
Loyal Hanna Coal and Coke Company, bituminous.	1,187.60	1,426.02	-	-	-	$4 34
Loyal Hanna Coal and Coke Company, bituminous.	854.39	742.61	-	-	-	4 69
Loyal Hanna Coal and Coke Company, bituminous.	662.00	595.64	-	-	-	6 86
Loyal Hanna Coal and Coke Company, bituminous.	-	-	487.15	-	-	5 22
Gillespie & Pierce, bituminous, . .	111.03	27.40	-	-	-	4 93
Gillespie & Pierce, bituminous, . .	8.26	43.56	-	-	-	5 60
Gillespie & Pierce, bituminous, . .	252.22	190.90	-	-	-	8 40
Gillespie & Pierce, screenings, . .	291.35	-	-	-	-	2 24
Locke Coal Company, bituminous, .	-	-	100.00	-	-	4 87
Locke Coal Company, bituminous, .	-	-	133.93	-	-	6 72
Locke Coal Company, buckwheat anthracite.	-	-	201.74	-	-	4 25
J. A. Whittemore's Sons, anthracite,	-	-	-	44.64	-	6 44
D. J. Cutter & Co., anthracite, . .	-	-	-	89.37	-	$6 05 to 7 84
D. J. Cutter & Co., bituminous, .	-	-	-	52.32	-	6 16 and 8 96
E. B. Townsend, bituminous, . .	-	-	-	22.32	-	11 20
D. Doherty, bituminous, ...	-	-	-	22.32	-	8 96
Pierce & Winn Company, bituminous,	-	-	-	-	267.44	4 76 to 8 68
Pierce & Winn Company, screenings,	-	-	-	-	61.94	2 22 to 2 55
Total gross tons, bituminous, .	3,075.50	3,026.13	721.08	96.96	267.44	-
Total gross tons, anthracite, .	-	-	201.74	134.01	-	-
Total gross tons, anthracite screenings.	291.35	-	-	-	61.94	-
Average price per gross ton, bituminous.	$5 34	$5 20	$5 45	$8 61	$5 91	-
Average price per gross ton, anthracite.	-	-	4 25	6 52	-	-
Average price per gross ton, anthracite screenings.	2 24	-	-	-	2 29	-

The necessary apparatus has been obtained for making tests of the viscosity, specific gravity and burning points of the oil, and of the

thermal value of coal used at the pumping stations, and tests are now made of the oil and coal as furnished. Fifty tests of lubricating oil have been made, and the oil now used is supplied in conformity with specifications prepared by this department. Thirteen tests of coal have been made, and the results have proved of value in selecting coal, although the state of the coal market during the greater part of the year was such that coal was purchased with little regard for quality.

Chestnut Hill High-service Station.

The supplies for the high-service district of Boston, the whole of the city of Quincy and the towns of Watertown and Belmont, and the greater part of the town of Milton after February 28, were pumped at this station. The 30,000,000-gallon Allis engine pumped 92.9 per cent. of the entire quantity pumped at the station.

The following are the statistics relating to the operations at this station: —

	Engine No. 1.	Engine No. 3.	Engine No. 4.	Totals.
Total quantity pumped (million gallons),	273.90	503.39	10,118.61	10,895.90
Total coal used (pounds),	380,417	443,134	8,078,166	8,901,717
Gallons pumped per pound of coal,	720.00	1,135.98	1,252.59	1,224.02
Average head pumped against (feet),	119.99	123.70	128.43	127.97
Cost of pumping: —				
Labor,	$971 25	$771 28	$12,540 53	$14,283 06
Fuel,	847 87	994 25	17,436 73	19,278 85
Repairs,	610 41	484 74	7,881 48	8,976 63
Oil, waste and packing,	44 67	35 47	576 75	656 89
Small supplies,	73 57	58 42	949 87	1,081 86
Total for station,	$2,547 77	$2,344 16	$39,385 36	$44,277 29
Cost per million gallons pumped to reservoir,	$9 302	$4 657	$3 892	$4 064
Cost per million gallons raised 1 foot high,	078	038	030	032

The cost per million gallons pumped to the reservoir was $0.48 more than in 1901, due to increased cost of fuel and repairs and to increase in the head pumped against.

Early in the year specifications were prepared for two 98-inch diameter vertical fire-tube boilers, from designs made by Dean & Main, mechanical engineers; and on February 24 a contract was

made with the I. P. Morris Company of Philadelphia for furnishing the boilers for the sum of $6,250 each. It was expected that the boilers would be delivered during the summer and placed in service before the end of the year; but the contractor experienced great difficulty in obtaining steel plates and other material of the high quality required, so that, although nearly finished at the shop, the boilers had not been delivered at the close of the year.

During the year new stay bolts were put in and other repairs made to the No. 4 boiler, and the American mechanical stoker which was in use with the boiler was replaced by a Continental shaking grate.

Three of the pump valves on engine No. 3 were fitted with new trunnions and trunnion boxes, and all three of the pump plungers were repacked. One leaky tube was replaced in the Wainwright heater connected with engine No. 4.

Chestnut Hill Low-service Station.

The three 35,000,000-gallon engines at this station have pumped a daily average for the entire year of 76,553,000 gallons.

The following are the statistics relating to operations at this station: —

	Engines Nos. 5, 6 and 7.
Total quantity pumped (million gallons),	27,941.95
Total coal used (pounds),	8,275,464
Gallons pumped per pound of coal,	3,376.48
Average head pumped against (feet),	42.48
Cost of pumping: —	
Labor,	$16,955 70
Fuel,	18,276 50
Repairs,	839 15
Oil, waste and packing,	705 74
Small supplies,	1,108 24
Total for station,	$37,885 33
Cost per million gallons pumped to reservoir,	$1 356
Cost per million gallons raised 1 foot high,	032

The cost per million gallons pumped to the reservoir was $0.146 less than for the year 1901.

The machinery at this station has continued to work satisfactorily, and is now in good condition. The only repairs made to the plant, with the exception of minor repairs made by the regular employés,

were a new valve wrist plate on the No. 5 engine, which was broken on account of a dry bearing, and new lifting levers on the upper valves of the low-pressure cylinders.

Spot Pond Pumping Station.

At this station engine No. 8 was not used during the year, all of the water having been pumped with engine No. 9, a 20,000,000-gallon Holly engine.

The following are the statistics relating to operations at this station: —

	Engine No. 9.
Total quantity pumped (million gallons),	2,919.01
Total coal used (pounds),	2,267,456
Gallons pumped per pound of coal,	1,287.35
Average head pumped against (feet),	123.73
Cost of pumping: —	
Labor,	$6,998 51
Fuel,	5,328 25
Repairs,	111 07
Oil, waste and packing,	211 09
Small supplies,	513 98
Total for station,	$13,162 90
Cost per million gallons pumped to reservoir,	$4 509
Cost per million gallons raised 1 foot high,	036

Engine No. 9 has given a much better duty than during the previous year, so that, notwithstanding an increase of 4 per cent. in the head pumped against and an increase of 5.5 per cent. in the quantity pumped, there was a decrease in the amount of coal used of 6.3 per cent. The cost per million gallons pumped to the reservoir was $0.328 less than during the previous year, although the cost of fuel was $0.85 per ton, or nearly 20 per cent. more than for the year 1901.

The machinery is in good condition, with the exception of a very small leak in the lower joint of the high-pressure steam cylinder on engine No. 9.

West Roxbury Pumping Station.

The water pumped at this station supplied the extra high-service district in West Roxbury for the whole year, and a portion of the town of Milton after August 22. The machinery has shown better economy, but the cost of pumping has been increased by increased cost of labor and fuel. The principal item of repairs was the sub-

stitution of Bannister shaking grates for the plain grates furnished with the boilers, which had become badly warped.

On January 4, Frank Matthews, the engineer in charge of this station, was given two months leave of absence on account of poor health. He died on August 6. He had been employed in the pumping stations of the Boston and Metropolitan Works for more than thirty years, and was a very faithful employé.

The following are the statistics relating to operations at this station: —

Pumps operated 4,701 hours; average, 13 hours per day.

Daily average quantity of water pumped (gallons),	352,000
Daily average quantity of coal consumed (pounds),	1,300
Gallons pumped per pound of coal,	271
Average lift in feet,	133
Cost of pumping: —	
Labor,	$3,239 33
Fuel,	1,679 93
Repairs and small supplies,	287 41
Total for station,	$5,206 67
Cost per million gallons pumped to reservoir,	$40 554
Cost per million gallons raised 1 foot high,	305

Arlington Pumping Station.

The supply for the high-service district of the town of Arlington was pumped at this station, and between September 4 and November 17, 4,320,000 gallons were also pumped for furnishing a portion of the supply of the town of Lexington.

The following are the statistics relating to operations at this station: —

Pumps operated 5,341 hours 5 minutes; average, 15 hours per day.

Daily average quantity of water pumped (gallons),	315,000
Daily average quantity of coal consumed (pounds),	1,922
Gallons pumped per pound of coal,	164
Average lift in feet,	278
Cost of pumping: —	
Labor,	$2,708 87
Fuel,	1,722 53
Repairs and small supplies,	263 17
Total for station,	$4,694 57
Cost per million gallons pumped to standpipe,	$40 769
Cost per million gallons raised 1 foot high,	147

The cost of pumping at this station shows an increase of $10.43 per million gallons pumped. This increase is due to an increase of 50 per cent. in the cost of fuel and of 30 per cent. in the cost of labor, the latter largely due to the employment of another engineer while water was supplied to the town of Lexington.

The 72-inch vertical boiler which was purchased from the city of Chelsea in 1901 was set up, covered with magnesia and connected with the pumps early in the year. During the year the old boiler has been examined and cleaned, the steam joints upon the compound pump repaired, and the boilers and pumps and the exterior of the building painted. A small concrete dam and new intake for the condenser pump were constructed at Mill Brook, the brook below the dam cleaned out, and the side-walls of the brook rebuilt.

Consumption of Water.

The daily average quantity of water consumed in the cities and towns of the Metropolitan Water District, supplied wholly or in part by the Metropolitan Works during the year 1902, was 107,268,000 gallons, equal to 123 gallons per inhabitant in the district supplied. Of the above, 107,186,000 gallons per day were supplied by the Metropolitan Water Works, and 82,000 gallons per day from local sources. The increase over the consumption of the previous year was 5,776,000 gallons per day, or 5.6 per cent. A small part of this increase was due to the addition of Milton to the territory supplied with Metropolitan water in 1902. If the water consumed in Milton in both years were included in making the comparison, then the increase during the past year would be 5,505,000 gallons per day, or 5.4 per cent. The increase in the quantity consumed per inhabitant was 3 gallons per day, or 2.5 per cent.

The consumption of water during the month of December was 20,000,000 gallons per day greater than during the month of November, and more than 6,500,000 gallons per day greater than in any previous month in the past. This was due to the use or waste of water to prevent the freezing of pipes. It is estimated that the total quantity of water used or wasted to prevent freezing during the colder months of the year was equivalent to a daily average consumption of 4,500,000 gallons for the entire year.

The consumption and percentage of increase over the previous year in the several districts was as follows: —

	Gallons per Day.	Percentage of Increase.
Southern low-service district, embracing the low-service district of Boston, with the exception of Charlestown and East Boston, ...	42,469,000	6.8
Northern low-service district, embracing the low-service districts of Somerville, Chelsea, Malden, Medford, Everett, Arlington, Charlestown and East Boston, ...	26,589,000	0.3
Southern high-service district, embracing the high-service districts of Boston, Quincy, Watertown, Belmont, and a portion of Milton, ...	29,543,000	11.5
Northern high-service district, embracing Melrose, Revere, Winthrop, Swampscott, Nahant and Stoneham, and the high service districts of Somerville, Chelsea, Malden, Medford, Everett and East Boston, ...	7,999,000	—1.2
Southern extra high-service district, embracing the highest portions of West Roxbury and Milton, ...	364,000	9.0
Northern extra high-service district, embracing the highest portions of Arlington, ...	304,000	—1.6
	107,268,000	

For reasons not entirely apparent, the consumption of the southern part of the District shows an increase, while that in the northern part was slightly less than during 1901. A reduction of about 475,000 gallons per day in the consumption of the northern high-service district was made in August by the stoppage of leaks in the street mains and services in the town of Stoneham; and the inspection which was made during the summer to prevent the unlawful use of hand hose without doubt tended to reduce the consumption through this district. During each of the last six months of the year the consumption of this district was less than during the corresponding months of the previous year, and the average for the last half of the year was more than 1,000,000 gallons per day less than for the same time in 1901.

The consumption of the southern high-service district was increased about 250,000 gallons per day by the addition of the town of Milton, and about one-half of the increase in the southern extra high-service district was also due to the same cause.

Detailed statistics of the consumption of water may be found in Appendix No. 3, tables Nos. 19 to 23.

Quality of the Water.

Samples of water were collected every two months from ten points, monthly from eight points and weekly from three points upon the works, and sent to the State Board of Health for analysis and examination. Samples of water were also collected each week from many points upon the works, and examined microscopically

and for color, odor, taste and turbidity by the biological force of the Metropolitan Water and Sewerage Board.

The quality of the water furnished was about the same as that of the previous year. The average color was slightly greater according to the State Board of Health examinations, and slightly less according to the Metropolitan Water Works examinations. As far as shown by the chemical examinations by the State Board of Health, the tap water of the main portion of the Metropolitan supply was somewhat better, while as far as concerns freedom from microscopical organisms it was not quite so good. The following table gives a comparison of the average results of examinations of Boston tap water, made for the years 1897 to 1902, inclusive. The additional supply from the South Branch of the Nashua River first reached the Metropolitan District about May 1, 1898.

	1897.	1898.	1899.	1900.	1901.	1902.
State Board of Health Examinations.						
Color (Nessler standard),	0.65	0.41	0.23	0.24	0.24	0.26
Total residue,	4.82	4.19	3.70	3.80	4.43	3.93
Loss on ignition,	1.84	1.60	1.30	1.20	1.64	1.56
Free ammonia,	0.0009	0.0008	0.0006	0.0012	0.0013	0.0016
Albuminoid ammonia, total,	0.0193	0.0152	0.0136	0.0157	0.0158	0.0139
Albuminoid ammonia, dissolved,	0.0177	0.0136	0.0122	0.0138	0.0143	0.0119
Albuminoid ammonia, suspended,	0.0016	0.0016	0.0014	0.0019	0.0015	0.0020
Chlorine,	0.40	0.29	0.24	0.25	0.30	0.29
Nitrogen as nitrates,	0.0137	0.0097	0.0137	0.0076	0.0173	0.0092
Nitrogen as nitrites,	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Oxygen consumed,	0.64	0.44	0.35	0.38	0.42	0.40
Hardness,	1.6	1.4	1.1	1.3	1.7	1.3
Metropolitan Water and Sewerage Board Examinations.						
Color (platinum standard),	0.59	0.40	0.32	0.34	0.34	0.33
Turbidity,	–	–	–	–	2.0	2.3
Total organisms,	351	230	192	468	243	367
Amorphous matter,	177	131	201	97	38	34
Bacteria,	105	96	117	181	162	164

NOTE. — Chemical analyses are in parts per 100,000, organisms and amorphous matter in standard units per cubic centimeter, and bacteria in number per cubic centimeter. The standard unit has an area of 400 square microns, and by its use the number of diatomaceæ are decreased, and the number of chlorophyceæ and cyanophyceæ are very much increased, as compared with the number of organisms.

A considerably larger supply of water than during the previous year was furnished to the Metropolitan District, owing to the increased consumption; and the greater part of this increase has been met by drawing an increased quantity from Framingham Reservoir No. 2. A somewhat smaller quantity was drawn from Lake Cochituate than during the preceding year. Although the water from Framingham Reservoir No. 2 is generally of less satisfactory quality than that from Framingham Reservoir No. 3, which comes

mainly from Sudbury Reservoir and the Nashua River, nevertheless, the quality of the supply as a whole has been maintained about the same as last year, by drawing the water from Framingham Reservoir No. 2 when at its best condition, and utilizing as far as possible the water in Ashland and Hopkinton reservoirs, which had been much improved by long storage.

Appendix No. 3, tables Nos. 24 to 30, gives the detailed results of chemical examinations of water in the various parts of the Metropolitan Water Works.

Biological Laboratory.

On April 28 Edward P. Walters, assistant biologist, was promoted to chief biologist, and he has been in charge of the laboratory throughout the year.

During the year 2,657 microscopical and 1,048 bacterial examinations of water were made at the laboratory of the Metropolitan Water and Sewerage Board, at No. 1 Ashburton Place, Boston. Of the microscopical examinations, 2,201 were of the regular weekly samples and 456 were made in connection with special examinations. Determinations of color, odor and turbidity have been made of all samples collected, and the temperature of the water has been noted in connection with all the regular weekly samples. Examinations of coal and of oil for use in the pumping stations have also been made in this laboratory.

The results of the color examinations are given in Appendix No. 3, Table No. 31, and the temperatures of the water and of the air in tables Nos. 32 and 33. Tables showing the results of the microscopical and bacterial examinations and the turbidity observations, which have been included in former reports, are omitted this year.

Sanitary Inspection.

The sanitary inspection of the Sudbury, Cochituate and Wachusett watersheds has been continued during the year, under the direction of William W. Locke, C.E., sanitary inspector. The greater part of the inspection has been done upon the Sudbury and Cochituate watersheds, where there is a large population; but a much larger amount of work than heretofore has been done on the Wachusett watershed, and the results obtained continue to be very satisfactory.

Cases of contagious diseases upon the Wachusett watershed and within the site of the Wachusett Reservoir have been few. In September five cases of typhoid fever were discovered in rapid succession in Holden among laborers employed upon the construction of the electric railway from Worcester to Holden. The water supplied the laborers was obtained from a spring near their camp and from three farmers' wells in the vicinity. On account of the proximity of privies and sink drains to the wells, they were closed at once, and water was temporarily furnished to the houses at the expense of the Board. Samples of the water from these wells were collected, and analyses gave unmistakable evidence of considerable previous pollution. Inquiry into the history of the farmhouses showed that typhoid fever had existed in recent years in all three of them. Upon presenting this information to the Board of Health of Holden, that Board at once permanently closed the wells and ordered the owners to dig new ones. No additional cases of typhoid fever developed.

The work of collecting statistics of population, sources of pollution, etc., on the Wachusett watershed, begun during the previous year, has been completed. For convenience of inspection and tabulation, the whole watershed has been divided into 13 districts, following the divides separating the watersheds of the various brooks. The data thus collected is presented in the following table: —

DISTRICT.	Premises.* Number.	Premises.* Occupied Permanently.	Premises.* Occupied Summers.	Premises.* Vacant.	Premises.* Deserted or in Ruins.	Area (Square Miles).	Population.† Permanent.	Population.† Summer.	Population per Square Mile.	Horses.	Cattle.	Sheep.	Swine.	Poultry.	Dogs.
French Brook,	73	63	–	8	–	4.65	309	–	66.4	76	270	–	47	2,654	29
Muddy Brook,	32	29	–	2	–	2.92	124	–	42.5	41	215	–	14	1,264	15
Gates Brook,	114	106	–	3	1	3.56	432	16	121.5	115	201	–	75	1,971	43
Malden Brook,	19	15	1	–	2	2.44	78	5	32.0	28	93	–	6	549	9
Chaffin Brook,	147	136	1	2	2	10.22	651	20	63.7	119	393	–	44	6,460	64
Asnebumskit Brook,	266	231	11	11	1	12.91	1,386	304	107.4	233	470	1	122	4,232	76
Musquapoag Brook,	105	82	5	11	4	11.67	370	89	31.7	107	456	–	66	4,469	48
South Wachusett Brook,	94	70	6	8	2	10.82	245	135	22.6	95	509	40	114	2,272	31
Trout Brook,	59	37	2	5	11	8.59	223	15	26.0	41	98	1	18	1,017	27
East Wachusett Brook,	225	162	24	16	11	21.26	568	324	26.7	236	683	–	90	4,291	79
Stillwater River,	181	160	1	8	7	11.59	720	43	62.1	156	679	29	106	4,705	67
Waushacum,	393	172	207	6	3	7.35	522	1,433	71.0	137	361	16	47	3,248	54
French Hill,	38	35	–	2	1	3.14	136	–	43.3	28	78	23	4	930	11
Totals,	1,746	1,298	258	82	45	–	5,764	2,384	49.0	1,412	4,506	110	753	38,062	553

* In the first column are also included 42 mills, carpenter shops, blacksmith shops, etc., and 21 cemeteries.

† Exclusive of persons employed in connection with the construction of the Wachusett Reservoir.

A summary of the work of sanitary inspection done in 1902 is given in the three following tables. The first table shows the number of premises inspected, the classification of cases inspected, and the condition of the premises at the end of the year for the Wachusett watershed. The second table gives the corresponding information for the Sudbury and Cochituate watersheds.

The headings of these tables explain themselves, except in a few instances; under the heading "Suspected" are included all cases where positive information could not be obtained, and where it is suspected that there may be some objectionable drainage; under the heading "Premises Vacant" are included all cases which at present furnish no objectionable drainage, but which might furnish such drainage if the premises were occupied; under the heading "Unsatisfactory" are included all cases where there may be, under the most unfavorable conditions, wash from privies or direct sink drainage, all suspected cases and all cases of manufacturing wastes entering feeders, even though there may be some attempt at previous purification.

The third table shows the improvements effected on the Sudbury and Cochituate watersheds in 1902. No cases are entered as remedied unless complete sewer connections have been made or all probability of future contamination has been removed, and no cases are entered as partly remedied except where positive improvement in the sanitary condition has been effected.

Summary of Sanitary Inspections on the Wachusett Watershed in 1902.

DISTRICT.	Number of Premises inspected.	Classification of Cases inspected.									Condition at End of Year.	
		Cesspools dug before 1902.	Cesspools dug in 1902.	Direct Privy Drainage.	Indirect Privy Drainage.	Direct Sink Drainage.	Indirect Sink Drainage.	Manure Piles.	Manufacturing Wastes.	Premises Vacant.	Satisfactory.	Unsatisfactory.
French Brook,	88	35	-	-	2	2	10	33	-	8	83	5
Muddy Brook,	31	8	-	-	-	1	8	20	-	2	29	2
Gates Brook,	121	43	19	-	3	4	20	56	-	3	112	9
Malden Brook,	18	7	-	-	-	-	2	14	-	-	16	2
Chaffin Brook,	143	26	3	-	5	7	34	81	1	2	125	18
Asnebumskit Brook,	262	93	9	2	10	30	25	109	2	11	214	48
Musquapoag Brook,	100	18	-	-	5	-	22	57	1	11	87	13
South Wachusett Brook,	89	15	-	1	5	4	7	43	-	8	79	10
Trout Brook,	49	4	-	4	3	1	5	28	1	5	45	4
East Wachusett Brook,	209	42	1	1	9	6	26	113	1	16	192	17
Stillwater River,	169	52	2	1	10	9	24	75	-	8	154	15
Waushacum,	179	50	1	3	6	19	24	67	-	6	150	29
French Hill,	37	14	-	-	1	1	6	17	-	2	33	4
Totals,	1,495	407	35	12	69	84	213	713	6	82	1,319	176

Note. — On some premises there are two or more cases.

Summary of Sanitary Inspections on the Sudbury and Cochituate Watersheds in 1902.

DISTRICT.	Number of Premises inspected *	Classification of Cases inspected.									Condition at End of Year.	
		Cesspools dug before 1902.	Cesspools dug in 1902.	Direct Privy Drainage.	Indirect Privy Drainage.	Direct Sink Drainage.	Indirect Sink Drainage.	Manure Piles.	Manufacturing Wastes.	Premises Vacant.	Satisfactory.	Unsatisfactory.
Sudbury Watershed.												
Farm Pond,	3	1	-	-	-	-	-	1	-	-	3	-
Framingham Reservoir No. 3,	7	4	-	-	-	-	3	1	-	-	4	3
Stony Brook,	57	33	2	-	-	2	3	11	-	3	50	7
Angle Brook,	359	190	9	1	2	8	68	30	5	29	300	59
Framingham reservoirs Nos. 1 and 2, and Cold Spring Brook,	28	16	2	-	-	-	5	2	-	3	25	3
Eastern Sudbury,	37	21	-	-	-	-	4	2	-	10	35	2
Indian Brook,	47	22	-	-	-	3	11	5	-	4	34	13
Western Sudbury,	25	13	-	-	2	-	6	4	1	-	18	7
Whitehall Reservoir,	5	4	-	-	-	-	1	2	-	-	3	2
Cedar Swamp,	53	30	-	-	-	-	9	-	1	3	44	9
Cochituate Watershed.												
Snake Brook,	37	15	2	-	3	-	11	5	-	1	26	11
Pegan Brook,	145	47	1	-	2	2	12	12	3	4	132	13
Course Brook,	6	4	-	-	-	-	2	1	-	1	4	2
Beaver Dam Brook,	109	62	-	-	2	3	20	12	3	3	86	23
Totals,	918	462	16	1	11	18	155	88	13	61	764	154

* Not including a large number of premises which were found on examination to be in a satisfactory sanitary condition, and likely to remain so. On some premises there are two or more cases.

Sanitary Improvements effected on the Sudbury and Cochituate Watersheds in 1902.

DISTRICT.	Remedied by Sewer Connection.	Otherwise remedied.	Partly remedied.	Cesspools abandoned on Account of Sewer Connections.
Sudbury Watershed.				
Farm Pond,	-	-	-	-
Framingham Reservoir No. 3,	-	-	-	-
Stony Brook,	-	-	2	-
Angle Brook,	35	2	9	35
Framingham reservoirs Nos. 1 and 2, and Cold Spring Brook,	-	-	2	-
Eastern Sudbury,	-	-	-	-
Indian Brook,	-	-	-	-
Western Sudbury,	-	-	-	-
Whitehall Reservoir,	-	-	-	-
Cedar Swamp,	13	-	-	12
Cochituate Watershed.				
Snake Brook,	-	1	2	-
Pegan Brook,	63	1	1	60
Course Brook,	-	-	-	-
Beaver Dam Brook,	25	3	1	23
Totals,	136	7	17	130

There still remains on the Wachusett watershed one mill discharging polluting material into the stream, of which the owner not only refuses to remove the pollution himself, but also to allow the Board to remove it. Legal proceedings have been begun to compel this abatement.

In those towns where there are sewers, every endeavor has been made through the local boards of health to have unconnected houses connected with the sewers, and satisfactory progress has been made.

In Natick fixtures have been installed and sewer connections made with 63 houses, against 73 the previous year.

In Marlborough there have been 35 connections, against 44 the previous year.

In South Framingham 25 houses have been connected, against 28 the previous year.

The new low-level sewer along Beaver Dam Brook has made little progress, except in the completion of the crossing under the Sudbury Aqueduct, already described. There yet remains a short section to be laid along Herbert Street before house connections can be made with it, but there is now no apparent reason why the sewer should not be available early next summer.

In Westborough 13 sewer connections have been made, against 17 the previous year.

Drainage of Swamps.

No additional ditches have been built during the year 1902. No material repairs have been made during the year to the ditches on the Sudbury watershed, but it has been necessary to replace some of the stone paving on the sides of the ditches on the Wachusett watershed where disturbed by cattle crossing them. The ditches tributary to the open channel, which have an aggregate length of 15.55 miles, have required, most of the time, two men to keep them in good condition, and in addition a foreman and five laborers worked for two weeks cutting bushes for a width of 25 feet on each side of the ditches.

Observations of the color of water from Crane Swamp and from the swamp southwest of Marlborough Junction, before and after draining, have been given in previous reports. For the year 1902 the average colors were, respectively, 1.08 and 0.61, which are substantially the same as for the previous year.

Distributing Reservoirs.

The distributing reservoirs maintained by the Board are the Chestnut Hill Reservoir, Waban Hill Reservoir and Forbes Hill Reservoir and Standpipe, of the southern high-service system; Spot Pond and the Mystic Reservoir near Tufts College, of the low-service system; the Fells Reservoir and Bear Hill Reservoir, of the northern high-service system; and the Arlington Standpipe, of the northern extra high-service system.

Chestnut Hill Reservoir.

The grounds around this reservoir constitute in effect a part of the park system, and are resorted to by great numbers of people, especially on Sundays and holidays. They have received the usual amount of care, and have been kept in good order. All the iron-work in the gate-houses has been painted. The force employed upon the maintenance of the reservoir has also assisted in cleaning the Sudbury and Cochituate aqueducts.

A large amount of labor has been required to clean the screens in effluent gate-house No. 2, through which nearly all the water used in the Metropolitan District is drawn. The screens have been largely rebuilt during the year, using a No. 3 mesh copper wire netting of No. 15 gage wire. Late in the year a rack extending about 3 feet below the surface of the water was built outside the gate-house, to intercept leaves and other floating substances which had previously clogged the screens.

Waban Hill Reservoir.

This reservoir has been in use throughout the year, and is now in good condition with the exception of the grass on the embankments, which was in very poor condition when the reservoir was purchased. Considerable labor, loam and fertilizing material have been used in an endeavor to obtain a good sod upon the embankments, but the results have thus far not been satisfactory.

Forbes Hill Reservoir and Standpipe.

The reservoir has been kept full of water in readiness for use in case of emergency, excepting from October 21 to November 17, while it was being cleaned. About 17 cubic yards of wet loamy material was removed from the reservoir, the greater part of which

blew into the reservoir from off the embankments before the grass had grown. The cost of cleaning was about $100.

The standpipe was shut off on May 18, emptied, and thoroughly scraped and cleaned on both outside and inside. The inside of the standpipe was then given a coat of red lead and linseed oil, and afterward two coats of Gilsonite varnish. All rusty places on the outside were given a priming coat of red lead, after which the whole outside was painted with two coats of white lead and oil paint of a gray color. The cleaning and painting were done by Sylvester Brothers, at a cost of $427.61.

While the standpipe was emptied it was discovered that there were voids between the steel plates and the concrete base. To remedy this, eleven holes were drilled through the bottom and tapped for 1-inch pipe. Through these holes, by the use of a force pump, cement grout, made with 5 parts of Portland cement, 3 parts of fine sand, with water enough to make a liquid mixture, was forced into the cavities until they were filled. About 9½ barrels of cement were used for this work.

Spot Pond.

On January 1, 1902, the elevation of the surface of the water in the pond was 163.78 feet above Boston City Base, or 0.78 of a foot above high-water mark. During the months of January and February, in order to avoid drawing water of unsatisfactory quality from Lake Cochituate, a portion of the supply was taken from Spot Pond, and its level was thereby lowered about 4.5 feet, to elevation 159.21 on February 26. The pond was gradually filled during March, reaching high-water mark on April 9, from which time until the early part of December it remained at or near high-water mark. The extreme cold weather about the middle of December, by increasing the water consumption beyond the capacity of the aqueducts, caused a lowering of the pond of about 0.7 of a foot. Before the end of the year a portion of this loss had been regained, and on December 31 the surface of the pond was 0.3 of a foot below high-water mark.

The exterior woodwork and roofs of two of the stone dwelling houses on the southerly shore of the pond have been thoroughly repaired and the woodwork painted. The stone house and barn on what was formerly the Wheildon estate have been taken down, the cellars filled and the ground loamed and seeded. Considerable time has been devoted to repairing riprap along the shore of the pond, cutting dead trees, and to destroying both brown-tail and gypsy moths.

Mystic Reservoir.

A new flight of steps has been placed at the northeast corner of the reservoir, and both reservoir and grounds are now in good condition.

Fells Reservoir.

This reservoir has been in constant use, and is now in good order. The ironwork of the gate-house floor has been painted.

Bear Hill Reservoir.

This reservoir was filled and placed in service on June 28, and has since been in constant use. The embankments were seeded in August, with very good results.

Mystic Lake.

An attendant has been kept at the lake to control the flow of water over the dam, and to care for the buildings and other property. The gate-house roof has been repaired, and a large hole below the dam, which was made by the water during freshets, has been filled with stones taken from a ledge on adjoining property of the Commonwealth.

Pipe Yards.

At both the Glenwood and Chestnut Hill pipe yards, pipes and special castings have been received and delivered for the several contracts in progress. The buildings at the Glenwood yard are in good condition. New ties and a few new rails were put in the side track at the yard, at a cost of $100.30. At the Chestnut Hill yard a wooden building, used as a carpenter and blacksmith shop, was destroyed by fire on June 18. A new building of somewhat larger size has been built for use as a carpenter shop and storehouse, and the blacksmith shop has been placed in another building. The new building was built by the maintenance force, with the exception of slating the roof.

The vehicles at both yards are in good order. A new one-horse caravan was purchased in November. Two horses which were unfit for use have been exchanged, and the number in the department is 10, as at the close of the year 1901.

Pipe Lines.

At the close of the year there were 82.09 miles of pipe lines owned and operated by the Board.

The principal items of work in connection with the maintenance of the pipe lines have been the relaying of the 16-inch pipe line supplying Winthrop and Breed's Island, which was made necessary by the abolition of the grade crossing of Winthrop Avenue and the Boston & Maine Railroad, and the raising of two 36-inch pipe lines at the crossing of the Mystic River between Somerville and Medford. At the crossing of the Boston & Maine Railroad in Revere 1,135.5 feet of 16-inch pipes were laid and 942.5 feet taken up, the increase in length being due to the laying of the pipes outside the line of the street in land of the Metropolitan Park Commission and the Boston & Maine Railroad. By this plan the pipes were laid alongside of the street under the railroad tracks, instead of over the bridge, and the maintenance of a temporary line during the construction of the bridge was avoided. This work, done by the maintenance force, cost $1,610.58.

At the Wellington Bridge crossing the Mystic River between Somerville and Medford the Metropolitan Park Commission is now building a bridge to replace the present structure, and in doing this work is constructing new abutments about 250 feet nearer the centre of the river than the present abutments on the Somerville shore. As the two lines of 36-inch pipes which were laid alongside the old bridge on a pile foundation below the river bed would be covered with earth by the new construction to a depth of from 8 to 17 feet, and as this was deemed for several reasons to be undesirable, the pipes have been raised and supported upon a new pile foundation. A contract for excavating the mud from around the pipes in the river and for building a coffer-dam and a pile trestle was made with Lawler Brothers of Charlestown on September 26. The work of dredging was begun on October 2 and finished October 27, after which piles were driven in bents of three, the bents being spaced 6 feet apart along the pipe. The alternate bents were capped with 4-inch by 10-inch double-girder caps, placed about 2 feet above the elevation to which the pipes were to be raised. Screws 8 feet long, passing through cast-iron plates bearing upon these caps and secured by wire ropes and chains to the pipes below at intervals of 12 feet, were used for raising the pipes to their new position, they having been first cut at each end of the section to be raised. After one line had been raised, 12-inch by 12-inch solid caps were placed under the pipes at intervals of 12 feet, the connections made at either end, and the line placed in service. The second line was cut, raised,

supported and connected in a similar manner. When this had been done, 6-inch by 12-inch double-girder caps were placed under both lines of pipes on the bents of piles which had been used in raising the pipes, thus giving bearings every 6 feet along the pipe line. With the exception of the dredging, trestle and coffer-dam, all the work was done by the maintenance force; and the whole cost, including the contract work, was $5,644.08.

The construction of the large Metropolitan sewer in Adams Street in Milton and Quincy, in close proximity to the 24-inch main supplying the city of Quincy, has required considerable attention for fear of possible damage to the pipe line. On account of this construction, portions of this pipe line are now laid in temporary locations; and there has been considerable settlement of the pipes, amounting to about 12 inches, for a distance of between 250 and 300 feet. As soon as weather will permit in the spring the temporary pipes are to be taken up, and the line raised and placed in good order.

But one break occurred on the pipe system during the year. This took place on Main Street near Ellis Avenue in Malden, on August 21, when a 30-inch pipe under about 96 pounds pressure split throughout its entire length, and a piece of pipe having an area of about 14 square feet was broken entirely away from the remainder of the pipe. Fortunately, the water which escaped during the thirty minutes before the gates were closed passed off into drains and sewers without doing serious damage to property. The streets and sidewalks in the vicinity were somewhat washed. So far as could be determined, the break was due to a point of the ledge through which the pipes had been laid bearing against the side of one of the pipes. The total cost of repairing the break, including damages to property, was $469.21.

During the year 10 leaks, due to defective joints, have been repaired, at a cost of $469.17.

In connection with the maintenance and operation of the pipe lines, the valves regulating the elevation of water in the Chelsea and Revere reservoirs have been examined and cleaned; and the Ross pressure-regulating valves on the pipes supplying Swampscott, Nahant and Revere have been cleaned and adjusted from time to time, as required. On October 10 the new standpipe built by the town of Nahant was placed in service, and in order to prevent its overflow, the pressure on the delivery side of the regulating valve was

reduced from 79 pounds to 62 pounds. The pressure-recording gages in use at different points on the pipe system have been tested.

Electrolysis.

On account of the large amount of construction work in progress during the year, very little time of the engineering force has been devoted to surveys or studies relative to the electrolysis of the water pipes. The return current on the cables of the Boston Elevated Railway Company at the crossing of the Charles River at the North Harvard Street Bridge was discovered to be grounded, passing into and thus endangering the pipes crossing the river at this point. The matter was reported to the railway company in June, and measurements taken in July indicated that the leakage of electricity had been stopped. In June a communication was received from the railway company, asking for the cooperation of the Board in making experimental tests of methods of preventing the electrolytic action on our 48-inch main in the vicinity of the North Harvard Street power station; and, after conferences to consider the proposed plan, permission was given the railway company to proceed with the work. An attempt has been made to protect the pipes at three points where it was thought the greatest damage was being done. One section 26 feet long, located opposite the power station, one 77 feet long crossed by three lines of tracks entering a car house, and one 39 feet long under two lines of track at a curve near Eliot Street, have been treated in the following manner: The pipes were first thoroughly cleaned with scrapers and wire brushes. A coat of asphalt paint was then applied, and over this a layer of Warren's "Kiola rock asphalt wire composition" was applied hot. A sheet of burlap was then wrapped around the pipe, and over this another layer of the hot asphalt was put on. The insulation was applied in short sections, which overlapped about 6 inches at the junction lines, and when completed was from ¼ to ½ an inch in thickness. As the trench was refilled, three lines of old tram rails were laid in the trench parallel with the axes of the pipes, and about 6 inches from the bells at the nearest point. These rails were connected to the pipe line by means of "0000" copper bonds soldered to the pipe bells near the ends of each insulated section. The rails were also connected at the ends with similar copper bonds. Where the pipe line was located under the car tracks, the rails were placed in a horizontal plane directly over the pipes, and opposite

the power station where there are no tracks in the street they were placed in a vertical plane. Arrangements have been made so that the amount of electricity flowing off from the rails can be measured, and also the amount flowing on the pipes. All of the pipes insulated showed the effects of the electrolytic action, and some of them had been very badly damaged. Careful measurements and plaster of Paris impressions of many of the pittings were made, for future reference. On one pipe there were about 80 pittings, varying in size from circles 1/4 of an inch in diameter to bands 30 inches long by 1 inch to 1 1/2 inches in width, and from 1/16 of an inch to 9/16 of an inch in depth.

No special investigations have been made of the condition of the pipes in Broadway in Chelsea and Broadway in Lynn, near the power stations of the Boston & Northern Street Railway Company; but it is probable that the injury to the pipes discovered at these points in 1901 has continued during the past year.

Prevention of Waste.

During the summer months inspections were made throughout the Metropolitan District for the purpose of observing violations of the regulations relating to the use of hand hose. The regulations forbid the use of hand hose between the hours of 8 A.M. and 5 P.M., and the use of revolving or fixed sprinklers at all times unless the water is metered. The inspections were made between the hours of 8 A.M. and 5 P.M., and the number and character of the violations reported are shown in the following table: —

Violations of Hose Regulations in Metropolitan Water District between May 27 and September 16.

	Rotary Sprinkler.	Fixed Sprinkler.	Hose on Fixed Support.	Hose held in Hand.	Totals.	Violations per 1,000 Inhabitants.
Boston,	6	12	18	59	95	.16
Arlington,	2	2	-	7	11	1.17
Chelsea,	-	-	1	9	10	.28
Everett,	4	-	13	25	42	1.57
Medford,	199	196	235	146	776	38.60
Melrose,	13	-	18	41	72	5.30
Nahant,	149	36	2	14	201	62.81
Quincy,	5	1	16	17	39	1.51
Revere,	-	-	8	4	12	1.01
Somerville,	8	5	16	58	87	1.33
Stoneham,	3	1	1	3	8	1.27
Swampscott,	60	27	20	55	162	23.48
Winthrop,	-	-	2	8	10	1.45
Totals,	449	280	350	446	1,525	-

An inspection of the table shows very plainly that the number of violations was very large in a few municipalities, and especially so in proportion to the population. The revolving lawn sprinklers, when allowed to run continuously, as is often done, use or waste large quantities of water, and in several municipalities these were found to be quite generally used. Violations of the regulations were reported to the water officials in the several cities and towns, and as the season advanced there was a decrease in the number reported, especially in the number of rotary and fixed sprinklers. This is shown by the following table: —

Number of Violations reported during the Months of June, July and August.

	June.	July.	August.
Rotary sprinklers,	264	93	60
Fixed sprinklers,	116	95	51
Hose on fixed support,	172	86	70
Hose held in hand,	168	106	135
Totals,	720	380	316

Measurements of the consumption of water in the town of Stoneham made during the early part of the year showed that it was about 790,000 gallons per day, or nearly 125 gallons per inhabitant. There is very little water used in the town for manufacturing purposes, and there appeared to be no good reason for so large a consumption; but the local authorities were not able to discover any leaks, either in the street mains and services or in the house plumbing, which would account for any considerable part of the water consumed. In order to localize the waste, the pipe system was divided into small sections, which could be supplied during the night through a meter placed in a line of 2½-inch fire hose between two hydrants. By this method a number of leaks from the street mains which gave no surface indications were discovered and repaired; and during October, November and December the daily average consumption was about 320,000 gallons, showing a saving of 470,000 gallons per day. On the high-service district of Arlington similar measurements have been made, and a few leaks have been found, the saving being about 30,000 gallons per day.

Clinton Sewerage.

The works have been in daily operation during the whole year. The amount of sewage pumped and filtered has been about 50,000 gallons per day less than during the previous year, the decrease being largely due to the discontinuance of a very leaky piece of 12-inch vitrified pipe sewer, which has since been reconstructed and again connected with the sewerage system of the town.

The regular force has been one engineer at the pumping station and two attendants at the filter-beds, one of the latter assisting the engineer at the pumping station a short time each morning. When additional help is required to furrow the beds, in the summer time to keep down the weeds or for other work, men employed on the maintenance of the Wachusett Aqueduct are transferred temporarily.

Following are statistics relating to the operation of the pumping station: —

Daily average quantity of sewage pumped (gallons),	786,000
Daily average quantity of coal consumed (pounds),	1,189
Gallons pumped per pound of coal,	661
Number of days pumping,	365
Cost of pumping: —	
Labor,	$1,084 51
Fuel,	1,186 15
Repairs and supplies,	120 33
Total for station,	$2,390 99
Cost per million gallons pumped,	$8 34
Cost per million gallons raised 1 foot high,	18

Filter-beds.

During the warmer part of the year sewage was applied to the beds from which no soil was removed in about the same quantity per bed as to the 19 beds from which all soil was removed, but the former beds have not been used during the colder part of the year.

The sewage was pumped only during the day time. The method of applying the sewage varies with the season of the year. During the warmer portion of the year, say from May 1 to November 28, the sewage was applied to the beds at a rate which averaged about 27,000 gallons per acre per day. For the first half hour after beginning pumping in the morning, when the sewage contains more sludge than at other times, it was turned upon a single bed, which

was frequently cleaned. The remainder of the beds were used in rotation, and all the sewage pumped was run upon a single bed for about 1½ hours, which made the amount per application about 209,000 gallons, and caused each bed to be used about once in 8 days. During the colder portion of the year the method depended upon whether the temperature was below or above 15° above zero. On days when the temperature was below this point, all the sewage was turned upon one of 5 improved beds which had been prepared with furrows 3 feet 6 inches apart. The average amount of sewage per application was 752,000 gallons, and each furrowed bed was used about once in 12 days. When the temperature was higher than 15° above zero, the sewage was applied to the beds which had not been furrowed, at a rate of 358,000 gallons per application, and each bed was used about once in 10 days.

During previous years the results obtained during the last half of the year have been better than during the first half, but this year the reverse is true, as will be seen by the following results of chemical analyses: —

[Parts per 100,000.]

	January to June, inclusive.	July to December, inclusive.	Whole Year.
Albuminoid ammonia, sewage,	1.0117	1.0917	1.0517
Albuminoid ammonia, effluent,	0.0772	0.1009	0.0891
Per cent. removed,	90	88	89
Oxygen consumed, sewage,	9.92	7.77	8.85
Oxygen consumed, effluent,	1.01	1.29	1.15
Per cent. removed,	88	80	84

The percentage of organic matter removed during the last half of the year has not been as large as in previous years.

The nitrification during the last half of the year continues to be better than during the first half, but the difference is less marked than in previous years. The extent of the nitrification is indicated by the following statement of the amount of free ammonia and nitrates: —

[Parts per 100,000.]

	January to June, inclusive.	July to December, inclusive.
Free ammonia, sewage,	3.5950	5.0617
Free ammonia, effluent,	0.7014	0.6709
Per cent. removed,	78	85
Nitrogen as nitrates, effluent,	0.7500	1.2130

The cost of maintaining the filter-beds has been as follows: —

Labor,	$2,277 01
Repairs and supplies,	67 43
Total,	$2,344 44
Cost per million gallons filtered,	8 29

Appended to this report are tables of contracts giving the amount of work done and other information, a statement of the cement tests, a long series of tables relating to the maintenance of the Metropolitan Water Works, tables showing the length of main pipes and number of service pipes, meters and fire hydrants in the Metropolitan Water District, and a summary of statistics for 1902.

Respectfully submitted,

F. P. STEARNS,
Chief Engineer.

BOSTON, January 1, 1903.

REPORT OF ENGINEER OF SEWERAGE WORKS.

To the Metropolitan Water and Sewerage Board.

GENTLEMEN: — The following is a report of the operations of the Engineering Department of the Metropolitan Sewerage Works for the year ending December 31, 1902.

ORGANIZATION.

The engineering organization at the end of the year is as follows: —

Division Engineers: —

FREDERICK D. SMITH, .	In charge of maintenance, South Metropolitan System, and construction of High-level Sewer, in Quincy.
FRANK I. CAPEN, . .	In charge of construction, High-level Sewer, day-work sections 64 and 67 in Milton and Hyde Park, and contract sections 77 and 78 in Roxbury, and of maintenance and construction, North Metropolitan System.
C. BARTON PRATT, . .	In charge of construction, High-level Sewer, sections 65 to 76, inclusive, in Hyde Park, West Roxbury and Roxbury, and of Section 30, Neponset River valley intercepter.
FRANCIS L. SELLEW, .	In charge of construction, High-level Sewer, sections 47 to 50, inclusive, in Quincy.
SETH PETERSON, . .	In charge of construction, High-level Sewer, sections 51 to 63, inclusive, in Quincy and Milton.
FRANK A. EMERY, . .	In charge of draughting rooms and records.

Assistant Engineer: —

JOHN S. HODGSON, . .	In charge of special studies.

Stenographer: —

HENRY P. FIELDING, .	In charge of classification of engineering reports, claims and correspondence.

In addition to the above, there are employed 68 engineering and other assistants.

METROPOLITAN SEWERAGE DISTRICTS.

Areas and Populations.

During the year no changes have been made in the extent of the sewerage districts, the areas of which remain at 85 square miles for the North and 102 square miles for the South district, a total, inclusive of water surfaces, of 187 square miles.

The development of this area from the original district of 114 square miles, created by chapter 439 of the Acts of 1889 referred to in the last report, now includes the whole or parts of twenty-four cities and towns, as set forth in the following table: —

Table showing Areas and Estimated Populations within the Metropolitan Sewerage District, as of May 1, 1902.

	City or Town.	Area (Square Miles).		Estimated Population.	
North Metropolitan District.	Arlington,	5.20		9,600	
	Belmont,	4.66		4,700	
	Boston (portions of),	3.45		89,400	
	Cambridge,	6.11		98,000	
	Chelsea,	2.24		35,700	
	Everett,	3.34		27,600	
	Lexington,*	5.11		2,800	
	Malden,	5.07		36,500	
	Medford,	8.35		20,700	
	Melrose,	3.73		13,800	
	Somerville,	3.96		66,900	
	Stoneham,	5.50		6,400	
	Wakefield,	7.65		10,000	
	Winchester,	5.95		8,000	
	Winthrop,	1.61		7,200	
	Woburn,	12.71		14,800	
			84.64		452,100
South Metropolitan District.	Boston (portions of),	20.92		140,200	
	Brookline,	6.81		23,000	
	Dedham,*	9.40		7,200	
	Hyde Park,	4.57		14,100	
	Milton,	12.59		7,300	
	Newton,	18.03		37,200	
	Quincy,	12.56		26,500	
	Waltham,	13.63		25,600	
	Watertown,	4.04		10,700	
			102.55		291,700
	Totals,		187.19		743,800

* Part of town.

METROPOLITAN SEWERS.

Sewers Purchased and Constructed, and their Connections.

Within the Sewerage District there are now 89.32 miles of Metropolitan sewers. Of this total, 8.79 miles of sewer with the

Quincy pumping station have been purchased from cities and towns of the District, the remaining 80.53 miles of Metropolitan sewer having been constructed by Metropolitan boards.

The position, lengths and sizes of these sewers are given in the following tables, together with other data referring to the public and special connections with the system: —

North Metropolitan System.

CITY OR TOWN.	Size of Sewers.	Length in Miles.	Public Connections, December 31, 1902.	Special Connections. Character or Location of Connection.	Special Connections. Number in Operation.
Boston: —					
Deer Island,	6′ 3″ to 9′,	1.367	4	- -	-
East Boston,	9′ to 1′,	5.467	16	- -	-
Charlestown,	6′ 7″×7′ 5″ to 1′,	3.292	12	Navy Yard, Almshouse,	8
Winthrop,	9′,	2.864	7	Club house,	1
Chelsea,	8′ 4″×9′ 2″ to 1′ 10″×2′ 4″,	3.787	7	Bakery, Rendering works, Metropolitan Water Works blow-off,	3
Everett,	8′ 2″×8′ 10″ to 4′ 8″×5′ 1″,	2.925	5	Metropolitan Water Works blow-off,	1
Malden,	3′ 9″×4′ 1″ to 1′ 3″,	3.931*	23	Metropolitan Water Works blow-off, Private houses,	1 97
Melrose,	1′ 10″×2′ 9″ to 10″,	6.099†	28	Private houses,	96
Cambridge,	5′ 2″×5′ 9″ to 1′ 3″,	5.963	20	Slaughter-house, City Hospital,	2
Somerville,	6′ 5″×7′ 2″ to 1′ 10″×2′ 3″,	3.471	10	Slaughter-houses (3), Car-house,	1 1
Medford,	4′ 8″×5′ 1″ to 10″,	5.359	19	Private houses,	4
Winchester,	2′ 11″×3′ 3″ to 1′ 3″,	6.403	11	Tannery, Private houses,	2 2
Stoneham,	1′ 3″ to 10″,	.010	3	- -	-
Woburn,	1′ 10″×2′ 4″ to 1′ 3″,	.933	3	Glue factory,	1
Arlington,	1′ 6″ to 10″,	3.520‡	31	Private houses,	83
Belmont,§	- -	-	1	- -	-
Wakefield,§	- -	-	-	- -	-
		55.391‖	200		303

* Includes .988 of a mile of sewer purchased from the city of Malden.

† Includes .736 of a mile of sewer purchased from the town of Melrose.

‡ Includes 2.631 miles of sewer purchased from the town of Arlington.

§ The Metropolitan sewer extends but a few feet into the towns of Belmont and Wakefield.

‖ Includes 2.787 miles of Mystic River valley sewer in Medford, Winchester and Woburn, running parallel with the Metropolitan sewer.

South Metropolitan System.

CITY OR TOWN.	Size of Sewers.	Length, in Miles.	Public Connections, December 31, 1902.	Special Connections. Character or Location of Connection.	Special Connections. Number in Operation.
Boston (Back Bay).	6' 6" to 5' 6",	1.500*	8	Private house, Administration building, Boston Park Department, Private estate,	1 1 1
Boston (Brighton).	5' 6" to 12",	3.714†	10	Abattoir,	3
Boston (Dorchester).	3'×4' to 2' 6"×2' 7",	2.870‡	6	- -	-
Boston (Roxbury).	6' 6"×7', 2' 0",	1.042	-	- -	-
Boston (West Roxbury).	9' 3"×10' 2" to 12",	6.565	3	Parental school, Lutheran Evangelical Church,	1 1
Brookline,	5' 6",	.127	2	- -	-
Dedham,	4'×4' 1" to 3' 9"×3' 10",	2.350	3	- -	-
Hyde Park,	10' 7"×11' 7" to 4'×4' 1",	4.511	11	Private buildings,	1
Milton,	11'×12' to 8",	3.538	3	- -	-
Newton,	4' 2"×4' 9" to 1' 3",	2.910	6	Private houses,	2
Quincy,	11' 3"×12' 6" to 60" pipe,	4.049	-	- -	-
Waltham,	3' 6"×4',	.001	1	- -	-
Watertown,	4' 2"×4' 9" to 12",	.750§	5	Factory,	2
		33.927	58		13

* Includes .355 of a mile of sewer purchased from the city of Boston.
† Includes .026 of a mile of sewer purchased from the town of Watertown.
‡ Includes 1.24 miles of sewer purchased from the city of Boston.
§ Includes .025 of a mile of sewer purchased from the town of Watertown.

Cost of Construction.

The cost of the 89.32 miles of Metropolitan sewers enumerated above, including five pumping stations, siphons and appertaining structures, may be summarized as follows: *—

North Metropolitan System,	$5,621,869 52
South Metropolitan System,	5,542,032 10
	$11,163,901 62

Construction and Additions during the Year.

The last report indicated that 82.47 miles of Metropolitan sewers had been constructed to December 31, 1901. There has consequently been added, during the year under review, a length of 6.85 miles, wholly in the South Metropolitan district. This includes .93 out of a total of 1.27 miles of brick and pipe sewers, authorized by chapter 204 of the Acts of 1901 to provide additional sewerage facilities for the city of Newton and the town of Brookline in the Neponset River valley system. The remaining length of 5.92 miles con-

* For detailed statement of cost, see report of Board, p. 59.

sists of High-level Sewer, authorized by chapter 424 of the Acts of 1899, and referred to in detail later in this report.

The following table gives details of areas, populations, local sewer mileage and other data for the whole Metropolitan Sewerage System: —

North Metropolitan System.

Area (Square Miles).	Estimated Total Population.	Miles of Local Sewer connected.	Estimated Population contributing Sewage.	Ratio of Contributing Population to Total Population (Per Cent.).	Connections made with Metropolitan Sewers.	
					Public.	Special.
84.64	452,100	503.46	342,321	76.0	200	303

South Metropolitan System.

102.55	291,700	366.42	130,895	44.9	58	13

Entire Metropolitan District.

187.19	743,800	869.88	473,216	63.6	258	316

Of the estimated gross population of 743,800 on December 31, 1902, 473,216, representing 63.6 per cent., were on that date contributing sewage to the Metropolitan sewers, through a total length of 869.88 miles of local sewers owned by the individual municipalities. These sewers are connected with the Metropolitan system by 258 public and 316 special connections. It appears, also, that there has been during the year an increase of 39.83 miles of local sewer connected with Metropolitan systems, and that 18 public and 22 special connections have been added.

Pumping Stations and Pumpage.

The following table shows the average daily volume of sewage lifted at each of the five Metropolitan pumping stations during the year, as compared with corresponding volumes for the previous year: —

Pumping Station.	Average Daily Pumpage.			
	Jan. 1, 1901, to Dec. 31, 1901.	Jan. 1, 1902, to Dec. 31, 1902.	Decrease during the Year.	
	Gallons.	Gallons.	Gallons.	Per Cent.
Deer Island,	53,100,000	51,500,000	1,600,000	3.01
East Boston,	50,700,000	49,500,000	1,200,000	2.37
Charlestown,	31,000,000	29,800,000	1,200,000	3.87
Alewife Brook,	3,943,000	3,742,000	201,000	5.10
Quincy,	2,014,000*	2,229,000	215,000†	10.67†

* Part of year. † Increase.

CONSTRUCTION ON THE NORTH METROPOLITAN SYSTEM.

No additional Metropolitan sewers have been constructed on this system during the year.

The additional pumping plant at the Alewife Brook pumping station, authorized by chapter 424 of the Acts of 1898, had been installed by the contractor, the George F. Blake Manufacturing Company, previous to the date of the last report, but the full duty guaranteed had not been attained. The contractors having introduced various modifications in the plant, the tests specified in the contract were successfully made on March 28 and 29, and the plant was accepted by the Board.

The contract involved an engine of the vertical, cross-compound type, having between the cylinders a centrifugal pump rotating on a horizontal axis, supplied with steam by a vertical boiler, 4 feet 8 inches in diameter, together with the necessary steam piping and connections. The contract called for a capacity of 13,000,000 gallons per day, raised to an elevation of 13 feet above the level of the sewage in the pump-well, and a guaranteed duty of 50,000,000 foot-pounds.

The final 24-hour tests gave the following results: —

Time of run,	9 A.M. to 9 P.M.
Average speed of engine (revolutions per minute),	216.40
Average steam pressure (pounds),	121.30
Indicated horse-power: —	
High pressure,	27.20
Low pressure,	28.68
Total,	55.88
Total gallons pumped per twenty-four hours,	12,962,000
Average lift (feet),	13.09
Water horse-power,	29.83
Efficiency of pumps (per cent.),	53.40
Total coal burned (pounds),	2,711.00
Duty in foot-pounds per 100 pounds coal burned,	52,300,000
Total feed-water evaporated (pounds),	22,562.50
Evaporation per pound of coal (pounds),	8.32
Evaporation per indicated horse-power per hour (pounds),	16.80
Equivalent evaporation from and at 212° from temperature of boiler feed (pounds),	8.50

CONSTRUCTION ON THE SOUTH METROPOLITAN SYSTEM.

This consists of the completion of the Neponset River Valley Sewer extension for the relief of areas in Newton and Brookline, authorized by chapter 204 of the Acts of 1901, and of further progress on the High-level Sewer, authorized by chapter 424 of the Acts of 1899, the latter work having been under construction since November of that year.

Neponset River Valley Sewer, West Roxbury and Newton.

Section 30.

Division Engineer in Charge. — C. Barton Pratt.
Contractor. — Thomas J. Kelley, Brookline, Mass.

About 1,800 feet of this section were constructed in 1901, referred to in the last report. The remaining 4,915 feet have been constructed during the year under review. The section was completed July 1, and includes 2,353 feet of 24-inch brick sewer and 2,651 feet of 18-inch and 1,711 feet of 15-inch pipe sewers, a total length of 6,715 feet.

The average depth of excavation on the 24-inch and 15-inch sewers was about 10 feet, and on the 18-inch sewer about 8 feet.

For a distance of 450 feet at the upper end of the section, north of Vine Street, the 15-inch sewer passes through a bog meadow. The pipes in this portion of the work are supported on piling, averaging 18 feet in length.

Considerable difficulty was experienced in the low lands adjoining the brooks, owing to the flooding of the trenches by heavy rains and melting snows, involving delays of some weeks.

The average rate of progress on the brick sewer was 62 feet per week, with a maximum of 190 feet. On pipe sewers the corresponding rates were 114 feet and (for two openings) 622 feet.

High-level Sewer.

The most important structural work of the department during the year includes the continuation of work on the High-level Sewer in progress at the date of the last report, and new construction for this system entered upon during the year.

Surveys and general studies in connection with this work have been completed during the year. The final location along the whole length of nearly 17 miles has been described in earlier reports.

For purposes of construction, the High-level Sewer has been divided into 36 sections. The work on some of these embraces more than one contract, and a total of 46 constructional contracts is involved. Of these contracts, 29 have been completed and 12 are in process of construction, leaving 5 yet to be advertised. These include the laying of a second line of harbor outfall, the construction of sewers in embankments already constructed on sections 44 and 46, and the laying of 48-inch force-mains from the Ward Street pumping station and a 24-inch force-main from the Quincy pumping station to the High-level Sewer. Particulars of the sections along the entire route, to date, are condensed in the following table : —

Details of Contract Sections, High-level Sewer.

Number of Contract Section.	LOCATION.	Size of Sewer.	Total Length of Sewer (Feet).	Estimated Length in Trench (Feet).	Estimated Length in Tunnel. Earth (Feet).	Estimated Length in Tunnel. Rock (Feet)	Date of Contract.	Date named for Completion.	Date of Actual Completion. Previous to Jan. 1, 1902.	Date of Actual Completion. Since Jan. 1, 1902.	Contractor.
43	Quincy and Hull, — harbor outfalls.	Two 60-inch pipes.	5,424*	5,424†	-	-	May 28, 1902,	July 1, 1903,	-	-	Hiram W. Phillips, Quincy, Mass.
44	Quincy, — Nut Island and Hough's Neck, embankment, etc.						April 3, 1902,	-	-	Oct. 16, 1902,	W. H. Ellis, Boston, Mass.
	Quincy, — pile wharf and dredging.	11' 3"×12' 6",	1,539	1,539	-	-	April 7, 1902,	-	-	Oct. 15, 1902,	W. H. Ellis, Boston, Mass.
44	Quincy, — riprap and ballast on shore.						Sept. 26, 1902,	-	-	Nov. 12, 1902,	W. H. Ellis, Boston, Mass.
45	Quincy, — Island Avenue, Hough's Neck.	11' 3"×12' 6",	972	-	972	-	Oct. 14, 1902,	April 1, 1903,	-	-	Latta & Terry Company, Philadelphia, Pa.
46	Quincy, — Hough's Neck, embankment, etc.	11' 3"×12' 6",	791	791	-	-	Apr. 3, 1902,	-	-	Sept. 30, 1902,	John Cashman, Quincy, Mass.
46	Quincy, — private land and flats.						-	-	-	-	- -
47	Quincy, — private land, Ratchford and Sea streets.	11' 3"×12' 6",	3,162	3,162	-	-	Oct. 3, 1901,	-	-	Nov. 19, 1902,	Chas. G. Belden & Co., Quincy, Mass.
48, 49	Quincy, — culverts and embankments.	-	-	-	-	-	May 23, 1901,	-	-	Dec. 6, 1902,	Chas. G. Belden & Co., Syracuse, N. Y.
48	Quincy, — private lands,	11' 3"×12' 6",	5,880	5,880	-	-	Dec. 1, 1902,	Sept. 1, 1903,	-	-	Chas. G. Belden & Co., Quincy, Mass.
49	Quincy, — private lands (first contract).	11' 3"×12' 6",	1,997	1,997	-	-	May 23, 1901,	-	-	Feb. 19, 1902,	Chas. G. Belden & Co., Syracuse, N. Y., and Quincy, Mass.
	Carried forward, .	. . .	19,765	18,793	972	-					

* Mean of two lines. † One line, 5,290 feet long, included in contract.

Details of Contract Sections, High-level Sewer — Continued.

Number of Contract Section.	LOCATION.	Size of Sewer.	Total Length of Sewer (Feet).	Estimated Length in Trench (Feet).	Estimated Length in Tunnel.		Date of Contract.	Date named for Completion.	Date of Actual Completion.		Contractor.
					Earth (Feet).	Rock (Feet).			Previous to Jan. 1, 1902	Since Jan. 1, 1902.	
	Brought forward, .	. . .	19,765	18,793	972	-					
49	Quincy, — private lands (second contract).	11′ 3″×12′ 6″,	1,497	1,497	-	-	June 18, 1902,	Jan. 1, 1903,	-	-	Chas. G. Belden & Co., Quincy, Mass.
50	Quincy, — Sea Street and private lands.	11′ 3″×12′ 6″,	3,071	3,071	-	-	Oct. 3, 1901,	-	-	Oct. 22, 1902,	Chas. G. Belden & Co., Quincy, Mass.
51	Quincy, — Greenleaf Street.	11′ 3″×12′ 6″,	2,365	2,365	-	-	Jan. 19, 1901,	-	-	Mar. 27, 1902,	Thos. F. Moore, Syracuse, N. Y.
52	Quincy, — private lands, Upland Road and Adams Street.	11′ 0″×12′ 3″,	2,774	2,554	220	-	Oct. 1, 1901,	-	-	Nov. 29, 1902,	National Contracting Company, New York, N. Y.
53	Quincy, — Adams Street, private lands and Furnace Brook Parkway location.	11′ 0″×12′ 3″,	1,900	1,900	-	-	Oct. 1, 1901,	-	-	Dec. 6, 1902,	National Contracting Company, New York, N. Y.
54	Quincy, — Furnace Brook Parkway location and Adams Street.	11′ 0″×12′ 3″,	1,992	1,992	-	-	Oct. 1, 1901,	-	-	Sept. 27, 1902,	National Contracting Company, New York, N. Y.
55	Quincy and Milton, — Adams Street.	11′ 0″×12′ 0″,	3,556	929	2,237	390	Nov. 26, 1900,	-	-	Nov. 29, 1902,	H. P. Nawn, Boston, Mass.
56	Milton, — Adams Street,	10′ 7″×11′ 7″,	1,500	1,500	-	-	Nov. 26, 1900,	-	-	Feb. 8, 1902,	National Contracting Company, New York, N. Y.
57	Milton, — boulevard location, Adams Street to Pleasant Street.	10′ 7″×11′ 7″,	1,869	1,869	-	-	Oct. 23, 1901,	-	-	Oct. 4, 1902,	J. W. Bustin & Co., Syracuse, N. Y.
58	Milton, — boulevard location, Pleasant Street to Centre Street,	10′ 7″×11′ 7″,	2,560	2,560	-	-	Oct. 12, 1901,	-	-	Dec. 11, 1902,	Latta & Terry Company, Philadelphia, Pa.

59	Milton, — boulevard location, Centre Street to Randolph Avenue.	10′ 7′ × 11 7″,	2,568	2,568	-	-	Oct. 8, 1901,	-	-	Dec. 20, 1902,	H. P. Nawn, Boston, Mass.
60	Milton, — boulevard location, Randolph Avenue to Canton Avenue.	10′ 7″ × 11′ 7″,	1,609	1,609	-	-	Oct. 23, 1901,	-	-	Nov. 29, 1902,	J. W. Bustin & Co., Syracuse, N. Y.
61	Milton, — Brook Road, Canton Avenue to Pine Tree Brook.	10′ 7″ × 11′ 7″,	2,829	2,829	-	-	May 20, 1902,	May 1, 1903,	-	-	Chas. G. Belden & Co., Quincy, Mass.
62	Milton, — Brook Road, westerly from Pine Tree Brook.	10′ 7″ × 11′ 7″,	2,178	1,781	-	397	Nov. 17, 1900,	-	-	Mar. 22, 1902,	E. W. Everson & Co , Providence, R. I.
63	Milton, — Brook Road and private land to near Neponset River.	10′ 7″ × 11′ 7″,	2,262	2,262	-	-	Nov. 26, 1900,	-	-	April 5, 1902,	National Contracting Company, New York, N. Y.
64	Milton and Hyde Park, — Neponset River crossing.	Three 60-inch pipes, etc.	272	272	-	-	-	-	-	Dec. 31, 1902,	Day labor.
65	Hyde Park, — Mounponset, River and Baldwin streets.	10′ 7″ × 11′ 7″, 9′ 3″ × 10′ 2″.	900	900	-	-	Oct. 13, 1899,	-	April 12, 1901,	-	Beckwith & Quackenbush, Mohawk, N. Y.
66	Hyde Park, — Baldwin Street, Ruskin Road, private land.	9′ 3″ × 10′ 2″,	5,300	-	-	5,300	Oct. 13, 1899,	Oct. 1, 1901,	-	-	Ed. W. & John J. Everson, Providence, R I.
67	Hyde Park, — Stony Brook crossing, private land.	9′ 3″ × 10′ 2″, two 60-inch pipes.	328	328	-	-	-	-	-	April 23, 1902,	Day labor.
68	Hyde Park and West Roxbury, — private land, Ashland Street, Hadwin Way.	9′ 3″ × 10′ 2″, 8′ 9″ × 9′ 8″.	2,738	2,698	40	-	Oct. 13, 1899,	-	Dec. 8, 1900,	-	Beckwith & Quackenbush, Mohawk, N. Y.
69	West Roxbury, — Hyde Park Avenue.	8′ 9″ × 9′ 8″,	2,596	2,596	-	-	Oct. 13, 1899,	-	July 1, 1901,	-	Beckwith & Quackenbush, Mohawk, N. Y.
	Carried forward, .	. . .	66,429	56,873	3,469	6,087					

Details of Contract Sections, High-level Sewer — Concluded.

Number of Contract Section.	LOCATION.	Size of Sewer.	Total Length of Sewer (Feet).	Estimated Length in Trench (Feet).	Estimated Length in Tunnel: Earth (Feet).	Estimated Length in Tunnel: Rock (Feet).	Date of Contract.	Date named for Completion.	Date of Actual Completion: Previous to Jan. 1, 1902.	Date of Actual Completion: Since Jan. 1, 1902.	Contractor.
	Brought forward, .	. . .	66,429	56,873	3,469	6,087					
70	West Roxbury, — Larch Place, private land, South Street.	8' 9"× 9' 8",	3,748	3,748*	-	-	April 14, 1900,	-	-	July 10, 1902,	Charles Linehan, Cambridge, Mass.
71	West Roxbury, — South Street, private land.	8' 9"× 9' 8",	2,193	2,005	188	-	April 14, 1900,	-	July 19, 1901,	-	Chas. F. Taylor & Co., Syracuse, N. Y.
72	West Roxbury, — South Street.	8' 9"× 9' 8",	3,010	1,870	1,140	-	Sept. 29, 1900,	-	-	Feb. 6, 1902,	Jones & Meehan, Boston, Mass.
73	West Roxbury, — South and Centre streets.	9' diameter,	2,800	-	2,800	-	Nov. 3, 1900,	Jan. 1, 1903,	-	-	National Contracting Company, New York, N. Y. (part of); and day labor (part of remainder).
73	West Roxbury, — Centre Street.	9' diameter,	1,975	-	675	1,300	April 21, 1902,	April 1, 1903,	-	-	H. P. Nawn, Boston, Mass. (balance of section).
74	West Roxbury and Roxbury, — Centre and Day streets.	8' 3"× 9' 2", 6' 6"× 7' 0".	2,982	190	-	2,792	Sept. 17, 1900,	-	-	May 3, 1902,	H. P. Nawn, Boston, Mass.
75	Roxbury, — private land, St. Alphonsus Street.	6' 6"× 7' 0",	3,070	-	-	3,070	Oct. 11, 1901,	Nov. 1, 1902,	-	-	E. W. Everson & Co., Providence, R. I. (balance of section).
76	Roxbury, — St. Alphonsus, Ward, Smith, Oregon, Conant and Phillips streets.	48-inch pipe (force-mains).	1,503†	1,503	-	-	-	-	-	-	- -
77	Pumping plant for Ward Street pumping station.	-	-	-	-	-	Jan. 17, 1902,	Jan. 17, 1904,	-	-	Allis Chalmers Company, Milwaukee, Wis.

77	Roxbury, — Ward Street pumping station and connections.	-	457†	457	-	-	Oct. 8, 1902,	Dec. 1, 1903,	-	-	L. P. Soule & Son, Boston, Mass.
78	Roxbury, — Vancouver Street; pumping station to Charles River Valley Sewer.	6′ 6″ × 7′ 0″,	680	680‡	-	-	Oct. 7, 1902,	April 1, 1903,	-	-	Patrick McGovern, Boston, Mass.
	Totals, . . .	. . .	88,844	67,323	8,272	13,249					

* 3,470 feet of sewer included in contract. † Mean of two lines. ‡ 650 feet of sewer included in contract.

This table indicates that, exclusive of the 24-inch Quincy force-main, the High-level Sewer will have, when completed, a length of 16.83 miles, of which 16.04 miles have been contracted for in whole or in part. Of this length, 13.21 miles have been excavated to grade, in trench or tunnel, with the masonry sewer structure either fully completed or closely following the excavation in most of the sections. This leaves 2.83 miles on which excavation is at a less advanced stage or still to be begun, and .79 mile yet to be advertised. The table shows, further, that 12.75 miles of the total length of the High-level Sewer are designed to be constructed in open trench, the remaining 4.08 miles being in tunnel. The latter portion of the work will consist of 1.57 miles of earth tunnel and 2.51 miles of rock tunnel.

During the year approximately 27,000 cubic yards of rock have been excavated for sewer construction in tunnel and in open cut, and about 9,000 tons were quarried at Rock Island, in Quincy, for use in riprap, etc., on the adjacent sections 48 and 49. The above work, together with the loosening of compact earth on some sections, has involved the use of about 34 tons of dynamite or other explosives during the year.

Type of High-level Sewer.

The cross-section of the High-level Sewer is generally of the horseshoe type, with slightly pointed arch and curved invert. The horizontal diameter is about nine-tenths of the vertical. The sewers built during the year vary from 11 feet 3 inches by 12 feet 6 inches to 6 feet 6 inches by 7 feet in diameter. Concrete is largely used for sidewalls and invert backing, with either one or two rings of brick lining, the latter being used where any considerable head of ground water is present. In some cases concrete is also used for the arch, but as a general rule this is of 12-inch brickwork. Rosendale cement is used, under favorable conditions, for the outer ring of brickwork and for the arch, also for concrete, but the inner ring of the invert is always built in Portland. The relative use of these two classes of cement is further referred to on page 244.

A more detailed description of the work, as divided into sections, follows: —

HIGH-LEVEL SEWER — BRINGING OUTFALL PIPE OFF NUT ISLAND INTO POSITION FOR LOWERING.

Section 43, Quincy and Hull.

Division Engineer in Charge. — Frederick D. Smith.
Contractor. — Hiram W. Phillips, Quincy, Mass.

This section comprises the 60-inch cast-iron pipe outfalls, laid in trenches dredged in the bed of the harbor and extending from the outlets, at points one mile beyond low water, to the proposed screen-house near the northwesterly shore of Nut Island. Two lines, respectively 5,290 and 5,558 feet long, with outlets 1,500 feet apart, are contemplated at present, the shorter of these, known as the westerly line, being now under construction. The pipes were purchased by the Board under a separate contract, as noted in the last report, and stored at Barker's wharf, Quincy. They are spigot and socket pipes, 1½ inches thick, weighing 6 tons per standard 12-foot length. The contract for the dredging, laying, etc., was awarded May 28, 1902, and dredging was begun July 17.

The bottom of the pipes will have an average depth of about 9 feet below the bed of the harbor, and the trench is dredged 2 feet deeper, to a maximum of 53 feet below mean high water. The bottom of the trench is 10 feet wide, and the sides slope so as to give a mean top width of about 30 feet. The dredging is in stiff clay. In this trench 10-foot piles are driven in 5-foot bents of two piles each, at intervals of 6 feet. These are capped by spruce timbers set to the required grade, thus ensuring two points of support for each pipe. The piles are driven with the assistance of a vertical telescopic guide box, 35 feet long when closed, resting upon the bed of the harbor, and capable of adjustment to varying depths of trench and conditions of tide. In this contrivance, which was designed by the contractor, a cylindrical hammer, 10 feet long, descends upon a pile placed within the inner box. A 75-foot lighter is used for the pile-driving work.

The pipes are laid in 48-foot sections, consisting of three lengths of ordinary spigot and socket pipes and one length having the spigot turned to a slight taper for a length of 5½ inches. This spigot is temporarily inserted, upon the wharf, into the bell of a pipe which is to form the leading end of a section, and the lead space entirely filled with lead, but without calking. The spigot is then withdrawn, to be used as the rear end of the following section. The four pipes forming a section are then arranged, in their proper order, upon

a floating caisson, lashed to the side of a second lighter, the three ordinary joints being run and calked in the ordinary manner. The caisson is a heavy timber structure, of a special design patented by the contractor, 6 feet square outside and 52 feet long, built of 6-inch hard pine and divided by eight transverse bulkheads into nine compartments, which can be separately flooded. On one face of the caisson eight timber saddles, shaped to the external contour of the pipes, serve as a resting place for the pipe section, which is firmly secured by chains and turnbuckles. When filled with water the caisson is sufficiently heavy to sink, but when empty its flotation is sufficient to support a section weighing about 24 tons. On being released from the lighter, the caisson immediately turns over, so that the pipes are suspended from it in the water. Then, through openings controlled by plugs, the compartments are sufficiently flooded to sink the whole. Arrived at the bottom, and still attached to the caisson, they are adjusted by divers to line and grade upon the caps, and the tapered spigot is drawn home into the leaded bell of the preceding section by means of ratchet-jacks, actuated by levers. For the latter purpose the leaded bell is temporarily fitted with a collar, provided with four guides to ensure the entry of the tapered spigot without damage to the lead mould. When the pipes are finally secured in position by wedges spiked to the pile caps, the caisson is filled with water, thus rendering it too heavy to float, and released from the completed section. It is then hauled to the surface by steam-winches on the lighters, and the water is forced out of the compartments by an air-pump. The special joint between the sections is calked before the excavated material is deposited from scows in the trench and over the pipes.

The work was begun at the outlet, which consists of a special quadrant bend, about 11 feet in length and weighing nearly 11 tons, the thickness of metal being 2½ inches. The outlet pipe is surrounded by a rectangular timber casing 13 feet square and 10 feet deep, projecting 2 feet beyond the extreme dimensions of the pipe and filled with Portland concrete. It rests upon 12 piles, 22 feet long, and is surmounted and surrounded by a cut granite ring, 30 inches deep, in six pieces. Piling beyond the casing serves as a framework for a timber curbing, the interior space being covered by 18-inch slab paving laid upon coarse gravel filling, with its surface sloping from the top of the granite ring, which is about 2½

HIGH-LEVEL SEWER — LOWERING OF OUTLET FOR OUTFALL PIPE OFF NUT ISLAND INTO BED IN HARBOR.

feet above the harbor bed and 34 feet below high water. The pipes are laid in strong tidal currents, due to a mean tidal range of 10 feet, which prevent continuous diving work. A total of 922 feet of pipe has been laid to date, and the trench has been dredged to full depth for a further distance of 900 feet. When work was suspended for the winter, on December 24, the ordinary rate of pipe laying in working weather was about 100 feet per week.

Section 44, Quincy.

Division Engineer in Charge. — Frederick D. Smith.
(1) *Contractor for filled embankments.* — W. H. Ellis, Boston, Mass.
(2) *Contractor for pile wharf and dredging.* — W. H. Ellis, Boston, Mass.
(3) *Contractor for riprap and ballast on shore.* — W. H. Ellis, Boston, Mass.

Section 44 includes the screen-house and sand-catcher on Nut Island, and a length of 11 feet 3 inches by 12 feet 6 inches sewer connecting the latter with the tunnel section through Quincy Great Hill. It has a total length of 1,539 feet. The first contract, dated April 7, 1902, embraces the levelling of Nut Island and the construction to sub-grade of an embankment on the bar connecting the island with Hough's Neck, using for the latter purpose material removed from the island. Boulder concrete is placed under a portion of the embankment as a foundation for the intended sewer.

Work was begun April 17, 1902, upon the excavation for removing the upper part of the island, and the entire contract was completed October 16. The embankment is carried up to a height of about 21 feet above mean low water, with heavy ballast and riprap slopes finished 1 foot lower. The construction of the embankment to sub-grade required 34,000 cubic yards of filling and 38,000 tons of ballast and riprap. The upper part of the embankment, having a top elevation of about 27 feet above low water, with a top width of 25 feet, will be formed of the material excavated from the embankment when the outfall sewer is constructed within it, in the summer of next year. In the mean time, careful observations are being made of the settlement of the bar, due to the weight ot embankment imposed upon it. The maximum depth of this settlement, to date, is shown to be about 18 inches. The settlement is confined to a length of about 600 feet in the central section of the embankment. This length is now being super-weighted by depositing upon it excavated material from the adjoining tunnel, Section 45, so that a weight in excess of the ultimate load, due to the con-

struction of the sewer and the completion of the embankment, may be placed upon it in advance of these operations.

The second contract, dated April 7, 1902, included the construction of a pile wharf, 550 feet in length, extending easterly from the eastern shore of Nut Island to a point about 500 feet beyond low water; the dredging of an area of about 4,000 square yards, at the end of the wharf, to a depth of 8½ feet below low water; the deposit of 700 tons of riprap as a protection for the shore end, and the building of a masonry bulkhead. The wharf is in a very exposed location, liable to be swept by storms, with the possibility, also, of disturbance by ice in winter and early spring. It was therefore built in a very substantial manner, with heavy horizontal and diagonal bracing. The piles and braces are of oak, obtained partly from the wood lot on Section 48, acquired by the Commonwealth, and partly supplied by the contractor, who also furnished the hard pine and spruce lumber for the superstructure.

The pile driving was begun on May 22, and the entire work was completed on October 15, 1902.

The third contract, for the placing of riprap and rock ballast on the northerly and westerly slopes of Nut Island as a protection to the shore, was entered into on September 26, 1902. The work included about 11,000 tons of riprap and 3,000 tons of ballast, and was completed on November 12, 1902.

Section 45, Quincy.

Division Engineer in Charge. — Frederick D. Smith.
Contractor. — Latta & Terry Company, Philadelphia, Pa.

This is a tunnel section of 11 feet 3 inches by 12 feet 6 inches sewer, extending from near the northerly shore of Hough's Neck southeasterly along Island Avenue, under Great Hill, for a distance of about 972 feet. The contract was awarded October 14, 1902, and a start made with the work at the southerly end of the section on October 22 and at the northerly end on October 25. Instead of sinking a shaft, the excavation is carried on from inclines at either end, teams being used for the removal of the excavated material. The excavation is in compact hard-pan, in which explosives are used. Substantially no water is found in the headings. Since the commencement of the tunnel work, 450 feet of tunnel heading have been driven, at an average rate of 64 feet per week, with a maximum of 93 feet. To date, no masonry has been built in the headings.

Section 46, Quincy.

Division Engineer in Charge. — Frederick D. Smith.
Contractor. — John Cashman, Quincy, Mass.

The greater part of this section consists of an embankment crossing an angle of Quincy Bay, in which an 11 feet 3 inches by 12 feet 6 inches sewer is to be constructed. The section extends from a point on Island Avenue, about 780 feet southeasterly from Sea Street, southwesterly through private lands and across tidal flats to Prospect Avenue, a total distance of about 791 feet. The contract for the construction of the 600 feet of embankment to sub-grade was awarded April 3, 1902. Work was begun April 23 and finished September 30.

The design is similar to that described under Section 44, but with ballast and riprap on the seaward slope only. The sub-grade to which the embankment is carried is about 18 feet above mean low water; the finished elevation, to be attained when the sewer is built, will be about 9 feet higher. Three lines of 12-inch cast-iron pipes, controlled by valves, are laid through the embankment to connect the Fensmere Hotel pond with the Bay. In the length between stations 3+45 and 4+97, near the middle of the embankment, where considerable settlement was anticipated, a pile foundation, with a boulder concrete platform above it, was constructed up to the sub-foundation for the sewer. The construction of the embankment to sub-grade involved 10,000 cubic yards of filling, the material for which was taken from a lot near Prospect Avenue, acquired by the Commonwealth. About 7,000 tons of ballast and riprap were used on the slope of the embankment. The construction of the sewer in this embankment will be commenced next spring and completed during the summer months.

Section 47, Quincy.

Division Engineer in Charge. — Francis L. Sellew.
Contractor. — Charles G. Belden & Co., Quincy, Mass.

The leading features of this section of 11 feet 3 inches by 12 feet 6 inches sewer, 3,162 feet in length, were given in the last report. It extends from Prospect Avenue, through private land, Ratchford and Sea streets, to Darrow Street. The work was begun on October 31, 1901, and 300 feet of it had been completed prior to December 31, 1901. The excavation was generally in dry sand and gravel,

with a small amount of water between stations 0+00 and 22+50. From Station 28+00 to the upper end of the section, the sewer arch is depressed, by reversing the horizontal and vertical diameters, on account of the proximity of the street surface. The entire section was completed on November 19, 1902, showing an average rate of progress of 60 feet per week from the commencement, with a maximum of 145 feet.

Culverts and Embankments, Sections 48–49, Quincy.

Division Engineer in Charge. — Francis L. Sellew.
Contractor. — Charles G. Belden & Co., Syracuse, N. Y.

The last report fully described the nature of the work on embankments within which a large part of the sewer forming these two sections is to be constructed. They extend in a westerly direction, generally parallel to Sea Street, from the intersection of Sea and Darrow streets, through private and marsh lands to a point on the upland about 35 feet southeasterly from Sea Street, near the Adams homestead, a total distance of 9,375 feet. The total length of embankments is about 8,200 feet, of which about 7,080 feet fall within the present contract. This work, now completed, has involved a total of 166,000 cubic yards of filling to sub-grade of embankments. This is about 12 feet above the level of the marsh and 7 feet below the proposed finished grade.

At the date of the last report about one-third of the contract volume of filling had been deposited. This had resulted in a maximum vertical settlement of the embankments into the marsh slightly exceeding 4 feet, equivalent to a displacement of about 30 per cent. of the cross-sectional area of mud underlying their actual location, 100 feet in width. The observations have been maintained during the year, and indicate a maximum vertical settlement of about 9 feet, equivalent to a mud displacement of about 40 per cent., and a minimum settlement of about 2 feet, showing a mud displacement of about 18 per cent. The settlement has now practically ceased.

The whole of the embankment filling and the balance of work on the six masonry culverts under the embankments have been completed during the year. The contract having been completed on December 6, the average rate of filling has been 364 cubic yards, with a maximum of 800 cubic yards, per day.

The slopes are protected by riprap and ballast, 3 feet in thickness,

carried up to an elevation of 18 feet above mean low water, wherever exposed to wash of tide or floods. This protection extends, on the north side from Station 26+08 to Station 56+20, and on the south side from Station 5+70 to Station 58+90, making a total length of 8,332 feet of protected slopes. A total of about 10,500 cubic yards of riprap and 4,400 cubic yards of ballast has been used in this work.

Section 48 (Masonry Sewer in Embankment), Quincy.

Division Engineer in Charge. — Francis L. Sellew.
Contractor. — Charles G. Belden & Co., Quincy, Mass.

This contract embraces the construction of a brick and concrete sewer, 11 feet 3 inches by 12 feet 6 inches in diameter, in that portion of the embankments before described, forming Section 48 of the High-level Sewer, extending from the intersection of Sea and Darrow streets to a point in private land about 210 feet easterly from Palmer Street, a total distance of about 5,880 feet. The contract was awarded on December 19, 1902. Preparations are now being made for carrying out the work during the winter.

For about 1,700 feet of the total length the sewer will be built upon a pile foundation. To prevent decay of the piles, they will be cut off at an elevation of 7 feet above mean low water. A continuous pier of boulder concrete will be carried up from the piles to the under side of the sewer structure. The material excavated from the trench, within the embankment, will be used to complete the embankment to the finished elevation of about 19 feet above marsh level. It is anticipated that the entire section will be completed before the winter of 1903.

Section 49, Quincy.

Division Engineer in Charge. — Francis L. Sellew.
Contractor (for two contracts). — Charles G. Belden & Co., Syracuse, N. Y., and Quincy, Mass.

This section extends from a point in the upland, adjacent to Quincy marsh, southeast of Palmer Street, westerly across Palmer Street and through the marsh, in a course generally parallel to Sea Street, to a point in the upland about 35 feet southeasterly from Sea Street, near the Adams homestead, a distance of 3,494 feet. The construction of embankments on 1,200 feet of this length was included in the contract for embankments, sections 48 and 49, as already described.

The work of sewer construction was divided into two further contracts, under the earlier of which, dated May 23, 1901, 1,997 feet of sewer were built in trench between that date and February 19, 1902. This comprised three separate lengths of sewer in dry sand and gravel, at an average depth of 15 feet below the original surface. About 100 feet of this sewer were built during the year under review. The surplus material from the trenches was used in the formation of embankments over or adjacent to the sewer. The filling of the embankments and the construction of three culverts were completed previous to December 31, 1901, as described in the last report. For a length of 104 feet in embankment, between stations 5+13 and 6+17, tie-rods were built into the sewer arch, and the arch was re-inforced with concrete.

A trench machine was used for the excavation, except for a length of 150 feet at the end of the section, where a derrick was set up. An average of 40 feet of trench per week was excavated, with a maximum of 144 feet. The sewer elevation being above the elevation of ordinary high tides, no water was pumped from the trenches.

The second contract for sewer construction, dated June 18, 1902, was awarded to the same contractor. It includes 1,497 feet of sewer, in two lengths, built in embankments carried up from marsh level to sub-grade under previous contracts, together with the filling of the upper portions of these embankments with material excavated from the sewer trenches within the embankments. About 700 feet of the total length will be built on a pile foundation. As stated under Sections 48–49, culverts and embankments, continuous observations were taken to record the settlement of the embankments into the marsh, and the work of sewer construction was not undertaken until the stability of the embankments was practically assured.

About 650 linear feet of sewer have been completed under the second contract. As the work is in embankment, any spreading that might result from slight movements of the embankments is resisted by tie-rods built into the sewer arch, which is also re-inforced with concrete.

Section 50, Quincy.

Division Engineer in Charge. — Francis L. Sellew.
Contractor. — Charles G. Belden & Co., Quincy, Mass.

This section consists of 3,071 feet of 11 feet 3 inches by 12 feet 6 inches sewer, extending from a point in the upland, about 35 feet

southeasterly from Sea Street, near the Adams homestead, westerly through Sea Street and private lands to Greenleaf Street. It is nearly all in open cut, averaging 18 feet in depth, in dry sand and gravel. A short length, crossing the end of a pond, near Mount Wollaston Cemetery, is in embankment and built upon a boulder concrete foundation. For a length of 220 feet in Sea Street, a depressed cross-section is used, owing to the shallowness of the trench at that point.

Work was begun on October 28, 1901, and completed on October 22, 1902. This gives an average rate of progress of 60 feet per week, with a maximum of 130 feet.

Section 51, Quincy.

Division Engineer in Charge. — Seth Peterson.
Contractor. — Thomas F. Moore, Syracuse, N. Y.

This is an 11 feet 3 inches by 12 feet 6 inches sewer, in Greenleaf Street, extending from near the Mount Wollaston Cemetery to Hancock Street, a distance of 2,365 feet. At the date of the last report, 1,920 feet of sewer had been completed. The excavation, exceeding 20 feet in average depth, was in coarse sand and gravel, practically free from water, except for abont 200 feet at the upper end, where a pulsometer pump was used. The average rate of progress for the whole section was 50 feet per week, with a maximum of 102 feet. Special features of the work were described in the last report. The entire section was completed March 27, 1902.

Section 52, Quincy.

Division Engineer in Charge. — Seth Peterson.
Contractor. — National Contracting Company, New York, N. Y.

The length of 2,774 feet of 11 feet by 12 feet 3 inches sewer forming this section begins at the westerly end of Greenleaf Street, at Hancock Street, crosses Hancock and Adams streets, private lands, and New York, New Haven & Hartford Railroad (Plymouth Division) to Upland Road, and passes thence along Upland Road and Adams Street to beyond Oakland Avenue.

At the date of the last report, 280 feet of trench had been excavated. The excavation was in coarse sand and gravel for the first 300 feet. This was succeeded by clay, sand and gravel, overlying an average depth of 12 feet of rock, extending to within 100 feet of Adams Street, at its junction with Upland Road. For the next

600 feet the excavation was wholly in sand and gravel. Rock was found in the remainder of the section, averaging 12 feet in depth, with sand and gravel above. The work was all in open cut, with the exception of 220 feet of earth tunnel under the railroad location. A cable excavator was used in the open cut, except between Hancock and Adams streets, where derricks were set up.

Very little water was found. A 6-inch pump was located at the corner of Adams Street and Upland Road, and a 4-inch pump near the railroad location, but the volume pumped at no time exceeded 300,000 gallons per day.

Between Adams Street and the westerly line of the railroad location, the arch is re-inforced with concrete. The entire section was completed on November 29, 1902. An average rate of progress of 50 feet per week, with a maximum of 120 feet, has been attained. One 10-inch and five 8-inch branches have been inserted in the sewer for the drainage of local areas.

James Mooney and John Murphy, rock men on this section, were killed on January 24 by the explosion of a dynamite cartridge while engaged in removing the unexploded portion of a blasting charge.

On March 27, Dominic Risch, a laborer, was struck by a part of the moving hoisting machinery while crossing a trench on a brace. He fell to the bottom and was killed.

Section 53, Quincy.

Division Engineer in Charge. — Seth Peterson.
Contractor. — National Contracting Company, New York, N. Y.

This is an 11 feet by 12 feet 3 inches sewer in private lands and along the location of the Furnace Brook Metropolitan Parkway, extending westerly from Adams Street, southwest of Oakland Avenue, for a distance of 1,900 feet.

The work is all in trench, of which about 200 feet had been excavated at the date of the last report, in which reference was made to special features of construction. For the first 500 feet the excavation was in sand and gravel. This was followed by about 700 feet in rock, averaging 10 feet in depth, with clay, sand and gravel above. The remainder of the section, with the exception of a length of 200 feet in which rock again appeared, was in clay, sand and gravel. Cable and trench machines were used. The maximum flow of water in the trench was about 400,000 gallons per day.

For a length of 122 feet, where the sewer closely adjoins Furnace Brook, tie-rods were built into the arch and the arch was re-inforced with concrete.

The work was completed on December 6, 1902, showing an average rate of progress over the entire section of 31 feet per week, with a maximum of 83 feet.

A 10-inch and a 12-inch branch were inserted in the sewer for the convenience of local areas.

Section 54, Quincy.

Division Engineer in Charge. — Seth Peterson.
Contractor. — National Contracting Company, New York, N. Y.

Commencing in the location of the Furnace Brook Metropolitan Parkway, at a point about 1,600 feet northeasterly from its junction with Adams Street, this section, of 11 feet by 12 feet 3 inches sewer 1,992 feet in length, extends in a westerly direction through the Parkway location and Adams Street to a point in Adams Street near Eaton's ice pond.

The excavation was wholly in trench, of which 100 feet had been completed at the date of the last report. The excavation was in clay, sand and gravel, with a depth of 7 feet of rock in the bottom of the first 1,000 feet and 12 feet of blue clay overlaid by sand and gravel in the upper 990 feet. The average depth of trench was about 18 feet.

Trench machines were used for handling the excavated material. The volume of water found averaged about 500,000 gallons per day, increasing to 1,200,000 gallons when the adjoining marsh areas were flooded. Six-inch centrifugal and 4-inch piston pumps were used.

For a length of about 95 feet, where the sewer passes under Furnace Brook, the arch was re-inforced with Portland concrete. An 18-inch and a 10-inch branch were built into the sewer toward the upper end of the section. The entire section was completed on September 27, 1902. The average rate of progress was 45 feet per week, with a maximum of 123 feet.

Section 55, Quincy and Milton.

Division Engineer in Charge. — Seth Peterson.
Contractor. — H. P. Nawn, Boston, Mass.

This is an 11 feet by 12 feet sewer, extending in a westerly direction along Adams Street, from a point near Eaton's ice pond, in

Quincy, to a point near Church Street, in Milton, a total distance of 3,556 feet, of which 2,627 feet are in tunnel, including 390 feet in rock. The average depth of tunnel below the street surface was 45 feet.

The last report gave details of the methods adopted by the contractor from the commencement of the work on December 1, 1900, to December 31, 1901, with special reference to its division into tunnel and open cut, the character of the excavation and the large volume of water met with. At the latter date, 373 feet had been excavated in trench and 1,346 feet in tunnel, — a total of 1,719 feet; and the masonry sewer structure had been completed in 1,110 feet of this length.

A cableway was used for trench excavation. On the tunnel work an elevator was erected at shaft No. 1, about 850 feet from the lower end of the section; derricks were used at the other two shafts. Throughout the open trench work, the sewer arch was re-inforced with Portland concrete, which was also used for backfilling over the arch in 929 feet of tunnel. Sheeting and bracing were left in place throughout the open cut. Where dry packing was used over the arch in tunnel, concrete collars were introduced at frequent intervals, to prevent any movement of ground-water along the arch. The pumpage at the shafts averaged about 1,000,000 gallons per day, and attained a maximum of 1,500,000 gallons, rendering necessary the use of 6-inch piston pumps in shafts Nos. 1 and 3 and in the open cut near the end of the section, as well as a 10-inch pump, occasionally assisted by a 6-inch, in shaft No. 2.

A 100 horse-power boiler near the corner of Adams and Washington streets supplied steam for an air compressor and pumps at shaft No. 2, a dynamo for the electric lighting of tunnel, and, at times, for a stone crusher.

A 12-inch branch was inserted at Station 26+33. The section was completed on November 29, 1902, showing an average rate of progress, over the entire section, of 35 feet per week, rising to 88 feet.

Timothy Fitzgerald, a night worker on the tunnel headings, attempted to come to the surface, on the morning of February 6, by holding on to the bottom of the elevator after it had started. He was swept off when the elevator reached the surface platform, fell back into the shaft and was killed.

Section 56, Milton.

Division Engineer in Charge. — Seth Peterson.
Contractor. — National Contracting Company, New York, N. Y.

This sewer, 10 feet 7 inches by 11 feet 7 inches in diameter, is located in Adams Street, extending northwesterly from near Church Street to a point about 800 feet beyond East Milton station, a distance of 1,500 feet. Of this length, 1,460 feet had been excavated at the date of the last report, and the masonry structure was completed for a length of 1,345 feet. The entire section was completed February 8, 1902.

The work was in open trench at an average depth of 31 feet, with rock in bottom for almost the entire length, overlaid by gravel, sand and blue clay. The average depth of rock, from its surface to the bottom of the trench, was about 12½ feet, with a maximum of 23 feet. The volume of water met with was easily handled by a 4-inch piston pump and a 3-inch pulsometer. The excavated material was transported by a cable machine, except at the crossing of the Granite branch of the New York, New Haven & Hartford Railroad, where a derrick was used. The average rate of progress over the entire section was about 25 feet per week, with a maximum of 62 feet.

Section 57, Milton.

Division Engineer in Charge. — Seth Peterson.
Contractor. — J. W. Bustin & Co., Syracuse, N. Y.

This section, consisting of 1,869 feet of 10 feet 7 inches by 11 feet 7 inches sewer, occupies the centre of the proposed Milton boulevard from Adams Street to Pleasant Street. The work is in open cut, at an average depth of 22 feet. Portions of the line, aggregating 700 feet in length, are in a low embankment, formed by depositing surplus material from the sewer trench.

Work was begun October 31, 1901, and 300 feet of trench had been excavated at the date of the last report. In the first 350 feet, the excavation was in a very hard mixture of clay, gravel and sand; the succeeding 1,200 feet were in sand and gravel, with some clay and disintegrated slate ledge; the remainder of the excavation was in sand and gravel. A trench machine was used throughout.

The ordinary flow of water in the trench was from 15,000 to 18,000 gallons per day, but this increased, near Pleasant Street, to

500,000, with a maximum of 650,000 gallons. A 6-inch submerged centrifugal pump was used near this point and a 4-inch pump near Reservation Road. Eight 8-inch branches were built into the sewer for the drainage of local areas. The section was completed on October 4, 1902. The average rate of progress was 45 feet per week, with a maximum of 90 feet.

Section 58, Milton.

Division Engineer in Charge. — Seth Peterson.
Contractor. — Latta & Terry Company, Philadelphia, Pa.

This section of 10 feet 7 inches by 11 feet 7 inches sewer occupies the centre of the proposed Milton boulevard between Pleasant and Centre streets, a distance of 2,560 feet, in open cut, averaging 17 feet in depth. For a length of nearly 2,000 feet, the sewer is covered by an embankment formed of surplus earth from the trench.

At the date of the last report, trench had been partially excavated west of Pleasant Street for a distance of 600 feet. In the first 1,500 feet, the excavation was in sand and gravel and clay; the remainder of the section was in clay and gravel. An average thickness of 3 feet of peat formed the surface covering from Station 13+00 to the end of the section. A trench machine was used for the excavations.

The volume of water varied from 500,000 to 750,000 gallons per day, and was handled by a 6-inch centrifugal pump and a pulsometer.

The sewer arch is depressed at Unkety Brook, which is carried over the sewer by twin culverts, each 4 feet wide and 3 feet high. The branches inserted in the sewer for the drainage of local areas include one 18-inch, one 12-inch and eight 8-inch. The section was completed on December 11, 1902. Excluding the period from December 12, 1901, to March 27, 1902, during which all work on this section was suspended, the average rate of progress was 63 feet per week, with a maximum of 102 feet.

Section 59, Milton.

Division Engineer in Charge. — Seth Peterson.
Contractor. — H. P. Nawn, Boston, Mass.

This 10 feet 7 inches by 11 feet 7 inches sewer is located in the centre of the proposed Milton boulevard, and extends from Centre Street to Randolph Avenue, a distance of 2,568 feet. The entire section is in a low embankment, formed of surplus excavated mate-

rial, finished at boulevard sub-grade. The average depth of excavation below the original surface is 20 feet.

About 200 feet of trench had been excavated to grade prior to December 31, 1901. The excavation for the first 2,400 feet was in clay and gravel, with pockets of sand and gravel; the remainder of the section was in sand and gravel. Between stations 20+00 and 24+00 the material in the bottom 10 feet was so compacted as to require drilling and blasting for its removal. A cableway was used for excavation. A 6-inch piston and a 6-inch centrifugal pump handled the water in the trench, averaging about 250,000 gallons per day, rising to a maximum of 400,000 gallons. Eight 8-inch branches were built in the sewer for the drainage of local areas.

The section was completed on December 20. The average rate of progress was 42 feet per week, with a maximum of 90 feet.

Section 60, Milton.

Division Engineer in Charge. — Seth Peterson.
Contractor. — J. W. Bustin & Co., Syracuse, N. Y.

Still following the centre line of the proposed Milton boulevard location, this section of 10 feet 7 inches by 11 feet 7 inches sewer extends from Randolph Avenue to near the junction of Canton Avenue and Brook Road, a distance of 1,609 feet, in open cut, with an average depth of 19 feet. For about 1,000 feet of the above length, the sewer is in embankment, of a maximum height of 9 feet above the original surface, and formed of surplus material from the sewer trench.

Work on this section was begun on May 12, 1902. The excavation was in sand and gravel, with a surface layer of loam or peat, about 1½ feet in thickness. Between stations 5+00 and 7+00 peat excavation was found within 4 feet of the bottom of the trench. A trench machine was used for excavation. A 6-inch submerged centrifugal pump raised the water found in the trench, averaging 450,000 gallons, with a maximum of 600,000 gallons, per day.

Between stations 5+18 and 6+95, the sewer arch is re-inforced with concrete through the area of deep peat excavation. Six 8-inch branches are provided for drainage of local areas.

The section was completed on November 29, 1902, showing an average rate of progress of 50 feet per week, rising to 108 feet.

Section 61, Milton.

Division Engineer in Charge. — Seth Peterson.
Contractor. — Charles G. Belden & Co., Quincy, Mass.

This is a 10 feet 7 inches by 11 feet 7 inches sewer, commencing near the junction of Canton Avenue with Brook Road, and extending westerly along Brook Road and its widened location to a point about 20 feet northwesterly from Pine Tree Brook, a distance of 2,829 feet.

The section is in open cut, at an average depth of 25 feet. Work was begun on June 5, 1902. A length of 2,510 feet has been excavated to date, and 2,345 feet of masonry sewer have been built, equivalent to an average rate of progress of 83 feet per week. The first 700 feet of excavation were in sand and gravel. Clay, gravel and sand were found in the succeeding 700 feet, and from Station 17+00 to the end of the section. A length of about 316 feet remains to be excavated. Trench machines have been used. The volume of water in the trenches has averaged 600,000 gallons per day, with a maximum of 2,500,000 gallons. A 10-inch and a 6-inch centrifugal pump and two 4-inch pulsometers have been used.

Section 62, Milton.

Division Engineer in Charge. — Seth Peterson.
Contractor. — E. W. Everson & Co., Providence, R. I.

This section of 10 feet 7 inches by 11 feet 7 inches sewer commences near Pine Tree Brook and extends northwesterly along Brook Road to a point 530 feet beyond Ridge Road, a distance of 2,178 feet, of which 397 feet, near Ridge Road, are in rock tunnel. The average depth of the 1,781 feet in open cut is 27 feet. The open cut is in sand and gravel, with clay. Rock was found in the bottom of the trench for two-thirds of the section.

At the date of the last report the whole of the excavation in trench and tunnel had been completed, and only 200 feet of masonry sewer remained to be constructed. This was completed on March 22, 1902, showing an average rate of progress over the entire section of 35 feet per week, with a maximum of 113 feet.

A trench machine was used on the open cut and two air compressors and a dynamo at the tunnel. A 6-inch centrifugal pump, a 4-inch piston pump and four pulsometers were used to drain the

trenches and tunnel. The pumpage averaged 500,000 gallons per day, with a maximum of 750,000 gallons.

Four 8-inch branches, for local areas, were built into the sewer.

Section 63, Milton.

Division Engineer in Charge. — Seth Peterson.
Contractor. — National Contracting Company, New York, N. Y.

The 2,262 feet of 10 feet 7 inches by 11 feet 7 inches sewer, forming this section, extend in open cut, averaging 25 feet in depth, from a point in Brook Road, 800 feet easterly from the Metropolitan Blue Hills Parkway, along Brook Road and across the Parkway and Brush Hill Road to a point in Park lands southeast of Neponset River.

Previous to December 31, 1901, 1,882 feet of trench had been excavated and the masonry built for a length of 1,662 feet, as referred to in the last report, which also gave details of excavation. The average volume of water pumped from the commencement of the work to the end of September, 1901, amounted to 300,000 gallons per day; but this increased, in the period between the latter date and March, 1902, to 2,000,000 gallons, with a maximum of 3,300,000 gallons, per day. To handle these large amounts of ground-water it was necessary to install 10-inch, 6-inch and 4-inch centrifugal pumps, 6-inch and 4-inch piston pumps and a pulsometer. A cableway and a trench machine were used for the excavation. Two steam drills were used for rock found in the bottom of the trench for the first 600 feet. The work was completed on April 5, 1902. The average rate of progress on the entire section was 32 feet per week, with a maximum of 68 feet.

An 18-inch, a 10-inch and three 8-inch branches have been built into the sewer to provide for the drainage of local areas.

On March 31, Wesley Barker, carpenter, was killed by falling off a brace across the trench, while engaged, with other workmen, in raising a wooden arch centre.

Section 64, Milton and Hyde Park (Day Work).

Division Engineer in Charge. — Frank I. Capen.

This section includes three parallel lines of 60-inch cast-iron pipe, each 154 feet in length, under the Neponset River, with about 95 feet of 10 feet 7 inches by 11 feet 7 inches sewer, and two masonry

head-houses, the whole forming a connection, 272 feet in length, between sections 63 and 65.

The pipes are laid without depression under the bed of the river. The work was carried out by day labor, under the direct control of the engineer.

The river crossing was constructed within a coffer-dam, and operations were so arranged that little more than one-third of the waterway of the river was occupied at one time. Pile driving for the first section of the coffer-dam was begun on April 21, 1902. The excavation, at an average depth of 8 feet below bed of river, was in sand and gravel. An 8-inch centrifugal pump was used on the Hyde Park and a 6-inch on the Milton shore. The work was completed late in December.

Section 65, Hyde Park.

This section was completed prior to December 31, 1901, as referred to in the last report.

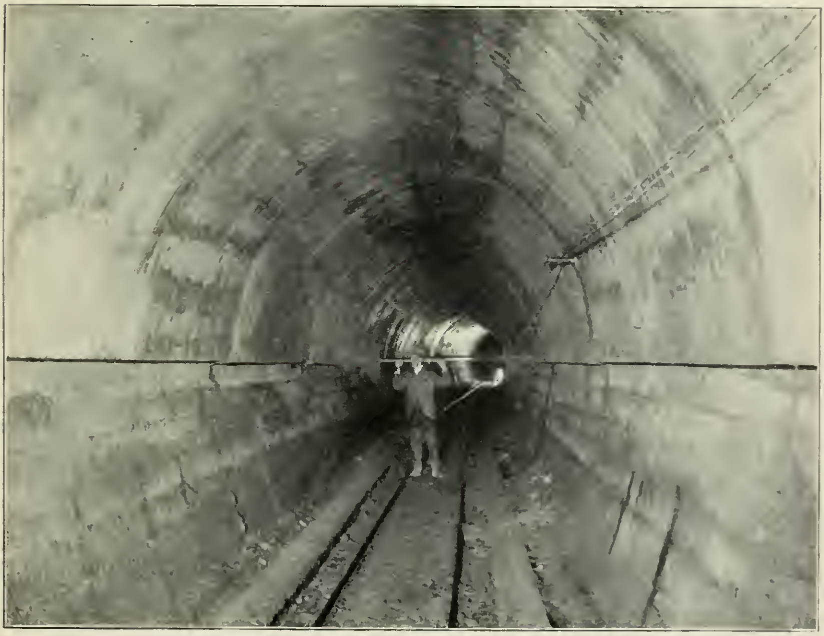
Section 66, Hyde Park.

Division Engineer in Charge. — C. Barton Pratt.
Contractor. — Ed. W. & J. J. Everson, Providence, R. I.

This section of 9 feet 3 inches by 10 feet 2 inches sewer, 5,300 feet in length, practically all in tunnel, has been described in earlier reports. It pierces the divide between the Stony Brook and Neponset River basins. The excavation is in rock, generally hard felsite.

During the year under review, the masonry lining of the tunnel has been begun and practically completed over the entire length of 5,015 feet, and the masonry has been built in the 285 feet length of open cut.

A Portland concrete arch was adopted in the tunnel, in place of the usual brick arch, except for a length of 79 feet under the location of the Midland Division of the New York, New Haven & Hartford Railroad. The concrete arch and sidewall backing were first put in place followed by a concrete invert, 10 inches in thickness. The invert and sides were then lined with 4 inches of Portland brickwork. These operations involved an average of 2.5 cubic yards of concrete and 0.203 cubic yards of brickwork per linear foot, with an average rate of progress, on the concrete, of 120 linear feet per week and 293 linear feet on the brickwork.



HIGH-LEVEL SEWER—ROCK TUNNEL IN HYDE PARK—STEEL RIBS AND CONCRETE LINING.

The contractor's plant included a single cage elevator for lowering materials into a central shaft 65 feet deep. A gravity mixer was used for the concrete, delivering into cars with a capacity of about 2½ cubic yards, and hauled through the tunnel by a small locomotive. Flanged sheet-iron plates, 5½ feet long and 16 inches wide, supported by 3-inch I-beam ribs carried down to the footings of the side-walls, were used for the concrete arch. A coat of thin oil applied to the lagging ensured a smooth-finished surface on the removal of the centres.

The tunnel was kept dry by a 6-inch underdrain leading to the shaft, where the water was lifted to the surface by a 4-inch pump. The volume of water handled was about 150,000 gallons per day.

The section is practically completed; the only work remaining to be done at the date of this report is the building of a manhole in the central shaft, 65 feet in depth.

Section 67, Hyde Park (Day Work).

Division Engineer in Charge. — Frank I. Capen.

This section connects the adjacent sections, 66 and 68, by two parallel lines of 60-inch cast-iron pipe, each about 86 feet in length, laid in concrete below the bed of Stony Brook, terminating at either end in head-houses connected with an aggregate length of 217 feet of 9 feet 3 inches by 10 feet 2 inches sewer, the latter having an average depth of about 18 feet. The pipes are not depressed. The total length of the section is about 328 feet. The whole of the work has been done by day labor, under the direct supervision of the engineer.

At the date of the last report, about 40 feet of pipe had been laid in each line, and the head-houses were under construction. The excavation was in sand and gravel, with many boulders. Rock was also found for a length of 75 feet at the easterly end. A 4-inch pulsometer pump was sufficient to handle the water until about March 1, 1902, when, owing to the flooding of the trench by freshets, a 6-inch centrifugal pump was used. The flow of Stony Brook was carried in a sluice-way, 12 feet wide, 4 feet deep and about 30 feet long, over the sewer trench. An incline was used to raise the excavated material from the sewer trenches. The work was completed on April 23, 1902.

Section 68, Hyde Park and West Roxbury; Section 69, West Roxbury.

These sections were completed prior to December 31, 1901.

Section 70, West Roxbury.

Division Engineer in Charge. — C. Barton Pratt.
Contractor. — Charles Linehan, Cambridge, Mass.

This section of 8 feet 9 inches by 9 feet 8 inches sewer commences in Hyde Park Avenue, and extends thence through Larch Place, under the main line of the New York, New Haven & Hartford Railroad, through the extension of Harrison Street, along private lands adjoining the railroad and Stony Brook, under Washington Street and in private lands to South Street, at Bussey arch, and along South Street to Bussey Street, a total distance of 3,748 feet. The actual length of sewer included in the contract is 278 feet less. With the exception of about 250 feet, the work was completed prior to December 31, 1901, and was fully described in the last report. The remaining length was completed on July 10, 1902.

Section 71, West Roxbury.

This section was completed prior to December 31, 1901.

Section 72, West Roxbury.

Division Engineer in Charge. — C. Barton Pratt.
Contractor. — Jones & Meehan, Boston, Mass.

This is an 8 feet 9 inches by 9 feet 8 inches sewer, commencing in South Street at the upper end of Section 71, and extending thence along South Street (crossing the Arborway) to the easterly side of St. Joseph Street, a total distance of 3,010 feet. Of this length, 1,140 feet were in earth tunnel, at an average depth of about 38 feet.

At the date of the last report, the whole of the open cut and all but 40 feet of the tunnel had been excavated. The masonry had been built in the entire length of open cut and in all but 100 feet of the tunnel. The structural features of the work were described in the last report. Near the end of Section 71 a small amount of water was found in the excavation, although the underdrain of that section had been carefully plugged in the usual way on its completion.

The entire section was completed on February 6, 1902, showing an average rate of progress of 44 feet per week.

Section 73, West Roxbury.

Division Engineer in Charge. — C. Barton Pratt.
Contractor. — National Contracting Company, New York, N. Y.
Contractor for Portion of Work. — Harry P. Nawn, Boston, Mass.
Superintendent of Construction by Day Labor. — Charles A. Haskin.

This 9-foot circular sewer, in South and Centre streets, extends from near St. Joseph Street to near Boylston Street. The entire length was designed to be in tunnel, at an average depth of about 50 feet; and, as the use of compressed air and shields was regarded as probable in the whole or portions of the work, the usual horseshoe type of sewer was abandoned in favor of a circular cross-section. Of the total length of 4,775 feet, it was anticipated that about 1,400 feet of the tunnel headings would be in Roxbury pudding stone, and the remainder in sand.

At the date of the last report, two shafts had been sunk to grade, one near Lakeville Place, in rock; the other at Pond Street, in sand. From the former, 1,300 feet of rock heading had been partially excavated, located about equally north and south of the shaft, and about 100 feet of concrete invert had been built in that length. At the Pond Street shaft a metallic shield and air compressors had been installed July 1, 1901, and a start made by the National Contracting Company to drive a southerly heading by the pneumatic process. As stated in the last report, no substantial progress had been made with this portion of the section on December 31, 1901, and this condition was maintained until the following February, when the Board took possession of the entire work, and have since carried on by day labor that portion of it extending for a length of 2,800 feet south of the Pond Street shaft. A contract for the completion of the remaining 1,975 feet was awarded to H. P. Nawn, of Boston, on April 21, 1902; and the work of lining the 1,300 feet of rock tunnel is now in progress, leaving about 675 feet of sand tunnel to be driven and lined with masonry under this contract.

The day-work portion, under the supervision of Mr. Charles A. Haskin, was commenced at the Pond Street shaft on March 26, 1902, and 600 feet of tunnel and masonry lining have been completed to date. The method used is the pneumatic process originally contemplated, a pressure of from 15 to 17 pounds per square inch in excess

of the atmospheric pressure being maintained in the headings. This is found sufficient to keep the headings dry, although the ground-water stands at an elevation of about 32 feet above the sewer invert. The excavation is in sand, with some gravel. The sand is very fine in places. The roof of the headings is supported by flanged steel plates, 3½ feet long by 1 foot wide, held by metallic sewer braces acting against a longitudinal needle-beam in the axis of the heading. The plate lining is carried down so as to occupy about two-thirds of the entire periphery of the headings. The cross-section of the sewer structure consists of a lining of Portland brickwork, approximately 12 inches thick, built directly against the interior face of the plates.

The plant at this shaft consists of two vertical boilers, which furnish power for the hoister and two air compressors.

A second day-work shaft, at Monument Square, was begun on April 18, 1902, and headings are now being driven in both directions from it. The shaft is 43 feet deep. The upper 20 feet consists of five sections of steel cylinder, 6 feet in diameter, resting upon a timber deck 20 inches thick. The remaining 23 feet of shaft below the deck, together with about 75 feet of the tunnel in very fine sand, were driven in each heading by the use of compressed air and a horizontal air lock at the surface, connected with the vertical cylinder. Air locks were installed in the completed sewer after these 75-foot lengths had been driven and lined, and the tunnel was then driven as described in the case of the Pond Street shaft, no further use being made of the surface air lock.

The progress to date, from this shaft, is 388 feet in a southerly and 345 feet in a northerly direction. The ground-water elevation in this part of the work is about 29 feet above the sewer invert.

The plant consists of one vertical and two horizontal boilers, aggregating 300 horse-power, which supply steam for a hoister and for three air compressors, as well as for small feed-pumps.

An aggregate of 70 feet per week is being regularly driven and lined on the day-work portion of the tunnel, a rate which will ensure its completion early in the coming summer.

HIGH-LEVEL SEWER — TUNNEL IN JAMAICA PLAIN BUILT WITH COMPRESSED AIR. METALLIC ROOF SUPPORTED ON NEEDLE BEAM.

Section 74, West Roxbury and Roxbury.

Division Engineer in Charge. — C. Barton Pratt.
Contractor. — H. P. Nawn, Boston, Mass.

This sewer, located in Centre and Day streets, extends from near Boylston Street, in West Roxbury, to near Heath Street, in Roxbury, a distance of 2,982 feet. A length of 190 feet between Hutchins Avenue and Minden Street is in open cut, in sand and gravel; the remainder is wholly in rock tunnel, with an average depth of 54 feet and a maximum of 65 feet. The lower portion, 1,000 feet in length, is 8 feet 3 inches by 9 feet 2 inches in diameter, changing to 6 feet 6 inches by 7 feet in a bell-mouth junction at Perkins Street. The sewer above that point forms a branch line to receive the sewage lifted at the Ward Street pumping station. The main line, above bell-mouth, is designed for the reception of high-level sewage of Roxbury, Brookline, Brighton, Newton and other areas, now flowing into low-level sewers of the Charles River Valley Sewer, and is not included in the present scheme of construction.

At the date of the last report, the tunnel excavation was completed and the sewer had been constructed in the open cut and in 1,800 feet of tunnel. The sewer construction in the remaining 992 feet of heading, including the bell-mouth, was completed May 3, 1902.

The ordinary volume of water in the heading was about 70,000 gallons per day, handled by two small steam pumps. A 100 horse-power boiler, installed at Perkins and Day streets, furnished steam for pumping, air compressors, electric lighting, etc. Excavation through the rock tunnel, over the whole length of the smaller sewer, progressed at an average rate of 31 feet per week, with a maximum of 60 feet. In the large heading it averaged 24 feet per week, rising to 40 feet. Dry packing was used over the completed arch, except where concrete was substituted to meet special conditions.

A fatal accident occurred on this section within a month after its completion. Patrick McCarthy, an experienced employé, as inspector and foreman, on Metropolitan Sewerage Works from their commencement, entered the deep manhole at Day and Perkins streets on the evening of May 26. At that time considerable groundwater had accumulated in the bulkheaded section. He was overcome by foul air while descending, fell to the bottom and was drowned.

Section 75, Roxbury.

Division Engineer in Charge. — C. Barton Pratt.
Contractor for Parts of Section. — E. W. Everson & Co., Providence, R. I.

This tunnel section of 6 feet 6 inches by 7 feet sewer, passing under Parker Hill, at a maximum depth of 175 feet, was described in the last report. It is 3,070 feet in length, and extends from the junction of Day and Heath streets, largely under private lands, for a distance of 1,700 feet before entering Calumet Street. It continues thence along St. Alphonsus Street to a point about midway between Tremont and Smith streets, where it is intended that the two 48-inch force-mains (Section 76) from the Ward Street pumping station shall deliver into the sewer.

At the date of the last report, the contractor had completed the pumping out of the second shaft, on St. Alphonsus Street, near Alleghany Street, which had been abandoned by a former contractor, and about 50 feet of heading had been driven from this shaft. During the present year the remaining 2,167 feet of tunnel have been driven, for the most part in hard, conglomerate rock. A pocket of hard-pan, about 100 feet in length, occurred at the crossing of Tremont Street, with disintegrated conglomerate adjoining it, at each end, for an aggregate length of 150 feet. In the same period the masonry sewer structure has been built in all but 300 feet of this part of the section. It consists of a concrete invert, lined with 4 inches of Portland brickwork, and an 8-inch brick arch backfilled with dry packing. In building the sewer, the concrete side-walls and the brick arch are first put in place, followed by the concrete invert and the invert lining of 4-inch brickwork.

The rock was drilled by the use of compressed air, supplied to drills set upon vertical columns.

The contractor installed at the St. Alphonsus Street shaft a single cage elevator for moving material and workmen, and an 80 horsepower boiler for operating two compressors, pumps and stone crusher. The crushed stone was transported by a belt conveyor to a hopper, and distributed into bins for future use in concrete. Progress on the tunnel headings included in the later contract averaged 43 feet per week, with a maximum of 76 feet.

Section 76, Roxbury.

This section embraces the two lines of 48-inch cast-iron force-main, traversing different routes and aggregating 3,006 feet in length, which will connect the Ward Street pumping station with the 6 feet 6 inches by 7 feet sewer on St. Alphonsus Street. A contract was entered into on December 26, 1902, with the Warren Foundry and Machine Company, for supplying the pipes required for this work. They are to be delivered during the winter and spring of 1903, in readiness for placing in the ground during the summer.

Section 77, Roxbury.

Division Engineer in Charge. — Frank I. Capen.
Contractor for Pumping Plant. — The Allis-Chalmers Company of Milwaukee, Wis.
Contractor for Pumping Station and Connections. — L. P. Soule & Son, Boston, Mass.

This section includes the pumping station, located at the southeasterly angle of Ward and Vancouver streets, Roxbury, and connections with the suction sewer and force-mains. A contract for furnishing and erecting two 50,000,000-gallon, vertical, triple-expansion, 60-inch stroke pumping engines, with boilers and other appurtenances, was entered into with the Allis-Chalmers Company of Milwaukee, Wis., on January 17, 1902. Substantial progress has been made to date in preparation for the erection of the pumping plant in the latter part of 1903. On October 8, 1902, a contract was entered into for the pumping station foundations, superstructure and connections. The station will be built of hard brick, with granite trimmings. The foundations will be of Portland concrete. The roof will be of steel and slate. The engine room will be about 120 feet long and 65 feet wide, the boiler room 105 feet long and 38 feet wide. The coal-house will be an underground concrete structure, about 48 feet long and 35 feet wide, with a coal capacity of about 400 tons. A screening chamber, about 47 feet long and 42 feet wide, adjoining the main buildings, is of the same type of construction as the main buildings and covers the passages in the suction sewer, in which movable screens will intercept rags and other floating matter which it is desirable to remove from the sewage before it reaches the pumps. The chimney will be 150 feet high and have a central flue 6 feet in diameter.

The excavation for the screen house and chimney foundations is completed, and some progress has been made in excavating for the foundations of the engine house and valve room; about two-thirds of the concrete in the chimney foundation is in place.

Section 78, Roxbury.

Division Engineer in Charge. — Frank I. Capen.
Contractor. — Patrick McGovern, Boston, Mass.

This section, 6 feet 6 inches by 7 feet in diameter, known as the suction sewer, will connect the existing Charles River Valley Sewer of the Metropolitan System with the Ward Street pumping station. It will extend from the pumping station lot, in Vancouver Street, northeasterly along Vancouver Street to the Metropolitan sewer in Ruggles Street, near Huntington Avenue, a total distance of about 680 feet. It will also include a smaller connection with the Metropolitan sewer for intercepting sewage to be conveyed by the reversal of the existing gradient in the Huntington Avenue sewer of the Metropolitan System. The present contract includes only about 650 feet of sewer. The actual connection with the Charles River Valley Sewer will not be made until the Ward Street pumping station and the High-level Sewer as a whole are in readiness for dealing with the diverted sewage.

The sewer is being constructed in trench at an average depth of 23 feet, with a pile foundation in the greater part of the length. Work was begun at the southerly end of the section on October 20 and near Huntington Avenue on November 6. The excavation is in clay, overlaid by deep beds of peat. The crossing of Huntington Avenue is attended by unusual difficulties, from the complication of sewers, water mains, electrical conduits and lines of street railway tracks, all of which have to be maintained while the work of piling and building the sewer is in progress. At the date of this report about half of the section is completed.

Cement Testing.

During the year, a total of about 109,000 barrels of Portland and 18,000 barrels of Rosendale cement have been used. The cement was subjected to the usual tests to determine its fineness, tensile strength, specific gravity and freedom from checking, cracking and other imperfections. In the following table, the results under the first two heads are summarized for the two and a half years: —

Summary of Cement Tests made by Metropolitan Sewerage Works, October 1, 1900, to December 31, 1902.

BRAND.	Number of Barrels used.	Composition of Briquettes.	Fineness.			Twenty-four Hours.		Seven Days.		Twenty-eight Days.		Three Months.		Six Months.		Nine Months.		One Year.		Eighteen Months.		Two Years.	
			Per Cent. Residue, No. 50 Sieve.	Per Cent. Residue, No. 100 Sieve.	Per Cent. Residue, No. 120 Sieve.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.
Portland.																							
Alpha, ...	4,481	Neat,	0	9.7	12.7	190	359	204	826	15	911	5	893	5	721	5	925	25	881	-	-	5	679
		2:1,	0	9.7	12.7	-	-	200	357	55	495	50	514	40	459	15	486	35	468	-	-	5	655
Alsen, ...	2,599	Neat,	0	10.0	12.6	60	467	60	681	-	-	-	-	-	-	-	-	5	817	-	-	-	-
		2:1,	0	9.9	12.4	-	-	45	344	5	495	5	537	5	590	-	-	5	608	5	574	-	-
Atlas, ...	88,845	Neat,	0	9.7	12.0	1,770	401	2,067	699	190	790	35	805	15	811	25	795	40	823	10	865	15	842
		2:1,	0	9.6	11.9	20	387	1,810	358	380	469	300	547	225	586	55	622	100	552	-	-	20	675
Brooks-Shoobridge, .	150	Neat,	0	10.0	13.4	35	367	45	568	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2:1,	0	10.0	13.3	-	-	35	245	-	-	15	483	-	-	5	481	5	568	-	-	-	-
Catskill, ...	1,427	Neat,	0	11.8	14.2	45	380	95	765	24	766	-	-	-	-	5	884	5	818	-	-	10	760
		2:1,	0	11.5	14.3	-	-	80	324	20	434	10	436	5	513	5	552	10	563	-	-	-	-
Lehigh, ...	44,862	Neat,	0	10.0	13.2	1,175	394	1,250	756	85	857	25	840	20	868	5	874	25	903	-	-	10	965
		2:1,	0	9.9	13.1	-	-	975	382	235	484	165	550	95	565	50	556	65	548	-	-	15	618
Star, ...	12,123	Neat,	0	9.5	12.0	430	380	415	769	50	850	5	814	-	-	10	895	34	889	5	702	15	915
		2:1,	0	9.7	12.1	-	-	349	350	100	437	40	435	35	491	20	537	35	543	5	545	30	596
Vulcanite, . . .	12,489	Neat,	0	9.5	11.7	390	380	425	833	55	854	10	785	15	831	5	847	30	950	10	832	10	794
		2:1,	0	9.4	11.6	-	-	380	485	130	539	110	586	70	615	20	593	30	594	5	597	10	557
Totals, . . .	166,976	Neat,	0	10.0	12.7	4,095	391	4,561	737	419	838	80	827	55	808	55	870	164	869	25	800	65	826
		2:1,	0	10.0	12.7	20	387	3,874	356	925	479	695	510	475	546	170	547	285	555	15	572	80	620

Summary of Cement Tests made by Metropolitan Sewerage Works, October 1, 1900, to December 31, 1902 — Concluded.

BRAND.	Number of Barrels used.	Composition of Briquettes.	Fineness.			Twenty-four Hours.		Seven Days.		Twenty-eight Days.		Three Months.		Six Months.		Nine Months.		One Year.		Eighteen Months.		Two Years.	
			Per Cent. Residue, No. 50 Sieve.	Per Cent. Residue, No. 100 Sieve.	Per Cent. Residue, No. 120 Sieve.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.
Rosendale.																							
Beach's, . . .	5,076	Neat,	4.0	16.0	19.0	90	143	125	144	5	230	-	-	5	316	5	410	-	-	-	-	-	-
		$1\frac{1}{2}:1$,	4.0	16.0	19.0	-	-	85	63	5	178	-	-	10	263	5	267	10	265	-	-	-	-
Crescent, . . .	408	Neat,	3.0	15.0	20.0	10	187	10	180	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		$1\frac{1}{2}:1$,	3.0	15.0	20.0	-	-	10	76	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hoffman, . . .	14,565	Neat,	3.6	15.5	17.7	340	143	355	155	45	261	10	322	5	304	-	-	15	407	-	-	-	-
		$1\frac{1}{2}:1$,	3.6	15.6	17.7	-	-	250	65	70	176	60	272	20	294	10	351	15	354	-	-	-	-
Newark and Rosendale,	14,618	Neat,	3.8	15.7	18.2	410	141	506	152	90	215	10	301	5	404	5	412	30	368	-	-	20	379
		$1\frac{1}{2}:1$,	3.9	15.9	18.4	-	-	450	69	80	149	45	244	20	288	10	240	30	269	5	267	20	240
Norton, ...	1,198	Neat,	3.2	13.6	15.8	175	150	220	156	49	190	15	303	-	-	-	-	5	363	-	-	10	451
		$1\frac{1}{2}:1$,	3.1	13.6	15.8	-	-	220	68	45	161	5	247	5	272	-	-	5	247	-	-	15	273
Olympia, . . .	5,495	Neat,	3.8	16.2	18.6	160	168	139	176	20	228	-	-	5	364	10	322	30	386	-	-	10	412
		$1\frac{1}{2}:1$,	3.7	16.4	18.7	-	-	158	63	25	164	25	315	15	323	5	398	30	275	-	-	15	244
Totals, . . .	41,360	Neat,	3.6	15.3	18.2	1,185	155	1,355	160	209	225	35	309	20	347	20	381	80	381	-	-	40	414
		$1\frac{1}{2}:1$,	3.6	15.4	18.3	-	-	1,173	67	225	186	135	270	70	288	30	314	90	282	5	267	50	252

MAINTENANCE.

Scope of Work and Force Employed.

The maintenance of Metropolitan Sewerage Systems includes the operation of five pumping stations and 89 miles of Metropolitan sewers, receiving the discharge from 869.88 miles of town and city sewers at 258 points, together with the care and study of inverted siphons under streams.

The present maintenance force of 80 men includes 47 engineers and other employés at the pumping stations, and 33 men employed on actual sewer maintenance and care of pumping station grounds. During the year the system of hiring teams was discontinued, and four single teams and equipment have been purchased by the Commonwealth. In the three following tables the use of the completed systems and other data are shown: —

NORTH METROPOLITAN SYSTEM.

Table showing Cities and Towns delivering Sewage in this System; Approximate Miles of Sewer connected; Estimated Populations and Areas now contributing; Total Areas ultimately to contribute, and Present Populations on Such Areas; Ratios of Present Contributing Areas to Ultimate Areas, and Ratios of Populations now contributing to Present Total Populations.

[Populations of December 31, 1902.]

CITIES AND TOWNS.	Miles of Local Sewer connected.	Separate or Combined.	Number of Connections with Local Sewers.	Estimated Number of Persons served by Each House-connection.*	Estimated Population now contributing Sewage.	Estimated Present Total Population.	Estimated Area now contributing Sewage.	Area ultimately to contribute Sewage.	Ratio of Contributing Population to Present Total Population.	Ratio of Contributing Area to Ultimate Area.
							Square Miles.	Square Miles.	Per Cent.	Per Cent.
Boston (Deer Island),	0.70	Separate,	–	–	1,100†	1,100†	–	–	100.0	–
Winthrop,	25.62	Separate,	1,592	4.3	6,846	7,200	1.21	1.61	95.0	75.3
Boston (East Boston),	20.00	Separate and combined.	5,006	8.8	44,053	47,400	.71	2.18	92.9	32.5
Chelsea,	11.27	Combined,	1,330	6.8	9,044‡	35,700	.54	2.24	25.4	24.2
Everett,	37.53	Separate,	3,285	5.8	19,053	27,600	1.74	3.34	69.0	52.2
Malden,	46.23	Separate,	3,850	5.5	21,175	36,500	2.50	5.07	58.0	49.5
Melrose,	31.97	Separate,	2,109	4.2	8,859	13,800	1.57	3.73	64.2	42.2
Boston (Charlestown),	20.70	Separate and combined.	5,044	7.9	39,850§	40,900	.65	1.27	97.4	51.3
Cambridge,	111.89	Separate and combined.	14,048	6.8	95,525	98,000	4.92	6.11	97.5	80.6
Somerville,	82.98	Separate and combined.	11,914	5.3	63,145	66,900	3.27	3.96	94.4	82.6
Medford,	46.51	Separate,	2,774	6.0	16,645	20,700	2.42	8.35	80.4	28.9
Winchester,	19.51	Separate,	708	9.4	3,825	8,000	.98	5.95	47.8	16.5
Woburn,	12.30‖	Separate,	844	5.8	4,895	14,800	.89	12.71	33.1	7.0
Stoneham,	10.49	Separate,	414	4.4	1,821	6,400	.57	5.50	28.5	10.4
Arlington,	18.57	Separate,	744	6.4	4,760	9,600	1.63	5.20	49.6	31.4
Belmont,	7.19	Separate,	192¶	6.9	1,725	4,700	1.02	4.66	36.7	21.9
Wakefield,**	–	–	–	–	–	10,000	–	7.65	–	–
Lexington,**	–	–	–	–	–	2,800	–	5.11	–	–
Totals,	503.46	–	53,854	6.3	342,321	452,100	24.62	84.64	76.0	29.1

* Estimated from assessors' statement of the number of houses in each city or town, and the population from census of 1900 extended to 1902.
† Estimated by Superintendent J. R. Gerrish of the Institution on Deer Island.
‡ The Pearl Street district of Chelsea temporarily excluded, owing to connection not being properly maintained.
§ Including 30 persons at navy yard.
¶ Including 2 connections with McLean Hospital, having an estimated population of 400.
‖ Exclusive of Mystic River valley sewer and tanneries.
** Wakefield and Lexington not connected.

SOUTH METROPOLITAN SYSTEM.

Table showing Cities and Towns delivering Sewage to this System; Approximate Miles of Sewer connected; Estimated Populations and Areas now contributing; Total Areas ultimately to contribute, and Present Populations on Such Areas; Ratios of Present Contributing Areas to Ultimate Areas, and Ratios of Populations now contributing to Present Total Populations.

[Populations of December 31, 1902.]

Cities and Towns.	Miles of Local Sewer connected.	Separate or Combined.	Number of Connections with Local Sewers.	Estimated Number of Persons served by Each House-connection.*	Estimated Population now contributing Sewage.	Estimated Present Total Population.	Estimated Area now contributing Sewage.	Area ultimately to contribute Sewage.	Ratio of Contributing Population to Present Total Population.	Ratio of Contributing Area to Ultimate Area.
							Square Miles.	Square Miles.	Per Cent.	Per Cent.
Boston (Back Bay), .	21.42	Separate and combined.	1,392	15.8	21,900	22,500	1.12	1.61	97.5	69.6
Boston (Brighton), .	51.36	Separate and combined.	2,405	5.9	14,200	21,900	3.13	4.27	64.9	73.5
Brookline, . . .	53.61	Separate and combined.	2,758	6.9	19,000	23,000	3.04	6.81	82.8	44.5
Newton, ...	94.85	Separate, .	4,569	5.9	26,900	37,200	6.22	18.03	72.5	34.7
Watertown, . . .	30.41	Separate, .	1,467	5.4	7,900	10,700	1.74	4.04	74.0	43.2
Waltham, . . .	38.25	Separate, .	2,594	8.5†	22,050	25,500	2.40	13.63	86.5	17.6
Boston (Dorchester), .	12.85	Separate and combined.	1,002	6.8	6,800	39,700	.81	4.89	17.2	16.6
Milton, ...	3.39	Separate and combined.	78	5.5	430	7,300	.19	12.59	5.9	1.5
Hyde Park, . . .	17.11	Separate, .	609	8.8	5,360†	14,100	.95	4.57	38.0	20.8
Dedham, ...	3.32	-	17	5.0	85	7,200	.15	9.40	1.1	1.6
Boston (Roxbury), .	-	-	-	-	-	29,200	-	1.23	-	-
Boston (West Roxbury),	3.92	Separate, .	135	7.2	970	26,900	.24	8.92	3.6	2.7
Quincy, ...	35.93	-	952	5.6	5,300	26,500	1.79	12.56	20.0	14.3
Totals, . . .	366.42	-	17,978	7.3	130,895	291,700	21.78	102.55	44.9	21.3

* Estimated from assessors' statement of the number of houses in each city or town, and the population from census of 1900 extended to 1902.

† Estimated by City Engineer.

WHOLE METROPOLITAN SYSTEM.

Table showing Areas delivering Sewage to the Entire System, inclusive of added High-level Area; Approximate Miles of Sewer connected; Estimated Populations and Areas now contributing; Total Areas ultimately to contribute, and Present Populations on Such Areas; Ratios of Present Contributing Areas to Ultimate Areas, and Ratios of Populations now contributing to Present Total Populations.

[Populations of December 31, 1902.]

SYSTEM.	Miles of Local Sewer connected.	Separate or Combined.	Number of Connections with Local Sewers.	Estimated Number of Persons served by Each House-connection.	Estimated Population now contributing Sewage.	Estimated Present Total Population.	Estimated Area now contributing Sewage.	Area ultimately to contribute Sewage.	Ratio of Contributing Population to Present Total Population.	Ratio of Contributing Area to Ultimate Area.
							Square Miles.	Square Miles.	Per Cent.	Per Cent.
North Metropolitan, .	503.46	Separate and combined.	53,854	6.3	342,321	452,100	24.62	84.64	76.0	29.1
South Metropolitan, .	366.42	Separate and combined.	17,978	7.3	130,895	291,700	21.78	102.55	44.9	21.3
Totals, . . .	869.88	-	71,832	6.6	473,216	743,800	46.40	187.19	63.6	24.8

CAPACITY AND RESULTS.

The following tables summarize the pumping records for the year for the North Metropolitan and Quincy stations: —

Deer Island Pumping Station.

At this station are three submerged centrifugal pumps, with impellers or wheels 8.25 feet in diameter, driven by triple-expansion engines of the Reynolds-Corliss type.

Contract capacity of pumps: 45,000,000 gallons each, with 19-foot lift.
Average duty for the year: 49,800,000 foot-pounds.
Average quantity raised each day: 51,500,000 gallons.
Force employed: 3 engineers, 3 firemen, 6 screenmen and 1 reliefman.
Coal used: first-quality Cumberland, costing from $3.79 to $5.50 per ton.

Table of Approximate Quantities, Lifts and Duties at the Deer Island Pumping Station of the North Metropolitan System.

Months.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1902.						
January,	1,957,200,000	63,100,000	47,000,000	92,100,000	11.61	56,300,000
February,	1,686,700,000	60,200,000	46,500,000	112,700,000	12.10	55,400,000
March,	2,558,000,000	82,500,000	66,700,000	128,700,000	12.54	61,500,000
April,	1,899,300,000	63,300,000	45,200,000	114,700,000	11.84	57,400,000
May,	1,433,000,000	46,200,000	38,600,000	62,500,000	11.80	47,800,000
June,	1,196,000,000	39,900,000	36,000,000	48,600,000	11.18	43,300,000
July,	1,244,600,000	40,100,000	34,600,000	64,200,000	11.04	47,800,000
August,	1,212,800,000	39,100,000	31,600,000	52,100,000	11.09	43,600,000
September,	1,194,700,000	39,800,000	34,300,000	53,200,000	11.08	47,700,000
October,	1,319,700,000	42,600,000	34,300,000	70,700,000	11.15	43,500,000
November,	1,250,600,000	41,700,000	36,400,000	59,200,000	10.96	44,400,000
December,	1,862,200,000	60,100,000	42,100,000	100,800,000	10.95	49,100,000
Total,	18,814,800,000	-	-	-	-	-
Averages,	-	51,500,000	41,100,000	80,000,000	11.40	49,800,000

East Boston Pumping Station.

At this station are three submerged centrifugal pumps, with impellers or wheels 8.25 feet in diameter, driven by triple-expansion engines of the Reynolds-Corliss type.

Contract capacity of pumps: 45,000,000 gallons each, with 19-foot lift.
Average duty for the year: 54,500,000 foot-pounds.
Average quantity raised each day: 49,500,000 gallons.
Force employed: 3 engineers, 3 firemen, 6 screenmen and 1 reliefman.
Coal used: first-quality Cumberland, costing from $3.98 to $4.09 per ton.

Table of Approximate Quantities, Lifts and Duties at the East Boston Pumping Station of the North Metropolitan System.

Months.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1902.						
January,	1,896,500,000	61,200,000	45,000,000	90,100,000	15.72	62,500,000
February,	1,610,000,000	57,500,000	41,600,000	110,700,000	15.50	59,400,000
March,	2,496,000,000	80,500,000	64,700,000	126,700,000	16.25	62,500,000
April,	1,841,200,000	61,400,000	43,200,000	112,700,000	15.40	58,900,000
May,	1,370,700,000	44,200,000	36,600,000	60,500,000	14.84	56,400,000
June,	1,136,200,000	37,900,000	34,000,000	46,600,000	14.70	50,200,000
July,	1,182,600,000	38,100,000	32,600,000	62,200,000	14.69	48,100,000
August,	1,150,800,000	37,100,000	29,600,000	50,100,000	14.61	49,500,000
September,	1,134,700,000	37,800,000	32,300,000	51,200,000	14.58	50,900,000
October,	1,257,700,000	40,600,000	32,300,000	68,700,000	14.62	50,900,000
November,	1,190,600,000	39,700,000	34,400,000	57,200,000	14.74	50,100,000
December,	1,800,200,000	58,100,000	40,100,000	98,800,000	14.93	55,000,000
Total,	18,067,200,000	-	-	-	-	-
Averages,	-	49,500,000	38,900,000	78,000,000	15.05	54,500,000

Charlestown Pumping Station.

At this station are three submerged centrifugal pumps, two of them having impellers or wheels 7.5 feet in diameter, the other 8.25 feet in diameter. They are driven by triple-expansion engines of the Reynolds-Corliss type.

Contract capacity of pumps: two, 22,000,000 gallons each, with 11-foot lift; one, 60,000,000 gallons, with 8-foot lift.
Average duty for the year: 47,400,000 foot-pounds.
Average quantity raised each day: 32,500,000 gallons.
Force employed: 3 engineers, 3 firemen, 6 screenmen and 1 reliefman.
Coal used: first-quality Cumberland, costing from $3.98 to $4.09 per ton.

Table of Approximate Quantities, Lifts and Duties at the Charlestown Pumping Station of the North Metropolitan System.

Months.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1902.						
January,	1,055,600,000	34,100,000	26,300,000	45,300,000	7.99	49,800,000
February,	956,400,000	34,200,000	24,300,000	53,600,000	8.06	48,700,000
March,	1,288,500,000	41,600,000	33,600,000	56,700,000	8.68	58,200,000
April,	1,038,200,000	34,600,000	28,100,000	55,700,000	8.11	48,400,000
May,	951,200,000	30,700,000	22,800,000	34,800,000	7.63	44,800,000
June,	872,500,000	29,100,000	22,800,000	34,500,000	7.63	43,500,000
July,	931,500,000	30,000,000	24,200,000	39,300,000	7.72	48,300,000
August,	886,600,000	28,600,000	24,900,000	32,700,000	7.71	41,300,000
September,	916,100,000	30,500,000	25,200,000	35,100,000	7.70	46,300,000
October,	966,100,000	31,200,000	24,800,000	42,800,000	7.77	47,800,000
November,	900,600,000	30,000,000	24,200,000	35,000,000	7.59	45,000,000
December,	1,105,600,000	35,700,000	28,300,000	49,500,000	8.08	46,500,000
Total,	11,868,900,000	-	-	-	-	-
Averages,	-	32,500,000	25,800,000	42,900,000	7.89	47,400,000

Alewife Brook Pumping Station.

The plant at this station consists of the original installation of small commercial pumps and engines, *i.e.*, two 9-inch Andrews vertical centrifugal pumps, with direct-connected compound marine engines, together with the recent additions. The latter consist of a specially designed engine of the vertical cross-compound type, having between the cylinders a centrifugal pump rotating on a horizontal axis.

Contract capacity of the two original pumps: 4,500,000 gallons each, with 13-foot lift.
Contract capacity of new pump: 13,000,000 gallons, with 13-foot lift.
Average duty for the year: 20,700,000 foot-pounds.
Average quantity raised each day: 3,742,000 gallons.
Force employed: 2 engineers and 1 laborer.
Coal used: first-quality Cumberland, costing from $4.23 to $6.95 per ton.

Table of Approximate Quantities, Lifts and Duties at the Alewife Brook Pumping Station of the North Metropolitan System.

Months.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1902.						
January,	156,089,000	5,035,000	3,814,000	7,403,000	13.16	23,300,000
February,	128,324,000	4,583,000	3,229,000	10,531,000	13.14	24,700,000
March,	214,729,000	6,927,000	5,494,000	11,127,000	13.05	29,500,000
April,	160,462,000	5,349,000	2,978,000	7,698,000	13.25	25,400,000
May,	105,228,000	3,394,000	2,692,000	4,738,000	13.16	20,000,000
June,	86,577,000	2,886,000	2,204,000	3,478,000	13.13	18,900,000
July,	80,077,000	2,583,000	1,700,000	4,143,000	13.10	18,100,000
August,	76,265,000	2,460,000	1,784,000	4,201,000	13.04	16,700,000
September,	73,591,000	2,453,000	1,868,000	3,526,000	12.97	16,000,000
October,	86,685,000	2,796,000	1,994,000	6,076,000	13.00	17,700,000
November,	73,913,000	2,464,000	1,910,000	3,910,000	13.06	17,300,000
December,	123,185,000	3,974,000	2,330,000	7,639,000	13.02	20,700,000
Total,	1,365,125,000	-	-	-	-	-
Averages,	-	3,742,000	2,666,000	6,206,000	13.09	20,700,000

Quincy Pumping Station.

At this station are two compound condensing Deane pumping engines.

Contract capacity of pumps: one, 3,000,000 gallons, the other, 5,000,000 gallons, with 36-foot lift.
Average duty for the year: 31,400,000 foot-pounds.
Average quantity raised each day: 2,229,000 gallons.
Force employed: 3 engineers.
Coal used: first-quality Cumberland, costing from $4.75 to $5.25 per ton.

Table of Approximate Quantities, Lifts and Duties at the Quincy Pumping Station of the South Metropolitan System.

Months.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1902.						
January,	82,111,000	2,649,000	2,164,000	3,738,000	39.29	30,600,000
February,	65,701,000	2,346,000	1,706,000	3,703,000	37.07	30,500,000
March,	116,637,000	3,762,000	3,129,000	5,746,000	42.53	41,600,000
April,	89,340,000	2,978,000	2,350,000	4,161,000	40.24	38,500,000
May,	69,045,000	2,227,000	1,915,000	3,840,000	34.89	31,500,000
June,	57,614,000	1,920,000	1,713,000	2,111,000	34.08	31,900,000
July,	54,404,000	1,755,000	1,472,000	2,096,000	32.88	31,600,000
August,	51,348,000	1,656,000	1,508,000	1,761,000	32.62	28,700,000
September,	49,340,000	1,645,000	1,470,000	1,856,000	32.89	29,700,000
October,	53,280,000	1,719,000	1,552,000	1,900,000	31.66	27,500,000
November,	52,356,000	1,745,000	1,488,000	1,838,000	26.23	24,300,000
December,	72,831,000	2,349,000	1,807,000	3,022,000	32.48	30,000,000
Total,	814,007,000	-	-	-	-	-
Averages,	-	2,229,000	1,856,000	2,981,000	34.74	31,400,000

In the following tables the total cost of pumping and the rate per million foot-gallons at each of the five pumping stations are shown in detail: —

Average Cost per Million Foot-gallons for Pumping at the Deer Island Station.

Volume (18,814.8 Million Gallons) × Lift (11.40 Feet) = 214,489 Million Foot-gallons.

Items.	Cost.	Cost per Million Foot-gallons.
Labor,	$10,896 58	$0.05080
Coal,	6,741 94	.03143
Oil,	158 96	.00074
Waste,	38 60	.00018
Water,	1,263 20	.00589
Packing,	155 08	.00072
Miscellaneous supplies and renewals,	1,252 60	.00584
Totals,	$20,506 96	$0.09560

Average Cost per Million Foot-gallons for Pumping at the East Boston Station.

Volume (18,067.2 Million Gallons) × Lift (15.05 Feet) = 271,911 Million Foot-gallons.

Items.	Cost.	Cost per Million Foot-gallons.
Labor,	$10,322 05	$0.03796
Coal,	8,046 46	.02959
Oil,	160 67	.00059
Waste,	32 71	.00012
Water,	850 80	.00313
Packing,	60 83	.00022
Miscellaneous supplies and renewals,	1,294 64	.00476
Totals,	$20,768 16	$0.07637

Average Cost per Million Foot-gallons for Pumping at the Charlestown Station.

Volume (10,854.4 Million Gallons) × Lift (7.89 Feet) = 85,641 Million Foot-gallons.

Items.	Cost.	Cost per Million Foot-gallons.
Labor,	$10,146 41	$0.11848
Coal,	3,389 97	.03958
Oil,	204 61	.00239
Waste,	70 82	.00083
Water,	443 60	.00518
Packing,	81 93	.00096
Miscellaneous supplies and renewals,	1,001 94	.01169
Totals,	$15,339 28	$0.17911

Average Cost per Million Foot-gallons for Pumping at the Alewife Brook Station.

Volume (1,365.13 Million Gallons) × Lift (13.09 Feet) = 17,869 Million Foot-gallons.

Items.	Cost.	Cost per Million Foot-gallons.
Labor,	$3,047 68	$0.17055
Coal,	1,321 24	.07394
Oil,	174 54	.00977
Waste,	38 19	.00214
Water,	216 83	.01213
Packing,	26 78	.00149
Miscellaneous supplies and renewals,	351 94	.01969
Totals,	$5,177 20	$0.28971

Average Cost per Million Foot-gallons for Pumping at the Quincy Station.

Volume (814.00 Million Gallons) × Lift (34.74 Feet) = 28,279 Million Foot-gallons.

Items.	Cost.	Cost per Million Foot-gallons.
Labor,	$3,259 31	$0.11526
Coal,	1,625 78	.05749
Oil,	41 20	.00146
Waste,	10 03	.00036
Water,	137 76	.00487
Packing,	15 14	.00054
Miscellaneous supplies and renewals,	457 61	.01618
Totals,	$5,546 83	$0.19616

Material Intercepted at the Screens.

The sewage of the North Metropolitan District, on entering the three main line pumping stations and before reaching the pumps, is screened through cages, provided in duplicate, and raised or lowered by steam power. This intercepted material consists of rags, paper and other floating matter, and amounted to a total of about 1,540 cubic yards during the year. This is equivalent to about 2.2 cubic feet for each million gallons of sewage pumped at Deer Island.

Care of Special Structures.

During the year, an additional salt-water suction pipe has been provided at the southeasterly end of the Deer Island pumping station. This consists of a 12-inch cast-iron pipe, resting for the greater part of its length upon a pile structure carried out to a point nearly 400 feet beyond high water, with platform at an elevation of about 16 feet above high water. The pipe is turned down at the

end of this structure into a depth of about 6 feet of water at low tide, so as to remain submerged under extreme tidal conditions. The approval of this work by the Harbor and Land Commissioners was given on March 28, and by the War Department on April 30, 1902. The piles were driven by contract, and the remainder of the work was carried out by the maintenance staff.

About 250 tons of riprap were deposited over the Deer Island limb of the Shirley Gut siphon. This was required as a protection to that portion of the siphon which had been partially denuded by changes in the bed of the channel at this point. The riprap forms a protecting cover 3 feet in thickness. Permission for this work had been obtained from the Harbor and Land Commissioners on May 4, 1899, and from the War Department on June 15, 1899.

A permanent house has been placed over the shaft on the Charlestown shore end of the sewer crossing under the Mystic River. A contract for the work was entered into with Woodbury & Leighton, of Boston, on June 16, 1902, and the work was completed in August. The structure consists of a brick house 14 feet square and 9 feet high, with granite base course and other trimmings. It is covered with a tile roof, surmounted with a rotary ventilator intended to extract the gases which would otherwise accumulate in the shaft.

The usual studies of the flow in the Metropolitan sewers, siphons and outfall have been maintained. They indicate a desirable freedom from deposit, and satisfactory conditions generally.

Respectfully submitted,

WM. M. BROWN,

Engineer, Metropolitan Sewerage Works.

BOSTON, January 1, 1903.

APPENDIX.

Appendix No. 1.

Contracts made and pending during

Contracts relating to the

[Note. — The details of contracts made before

	1. Number of Contract.	2. WORK.	3. Number of Bids.	Amount of Bid. 4. Next to Lowest.	5. Lowest.	6. Contractor.
1	166	Excavating soil, . .	6	$1,248,400 00	$1,096,300 00*	Nawn & Brock, . .
2	183†	Excavating soil, . .	5	238,500 00*	230,685 00	Long & Little, . .
3	210	Excavating soil, . .	3	377,830 00	360,870 00*	Newell & Snowling Construction Company.
4	229†	Excavating soil from the Wachusett Reservoir and building a part of Worcester street in West Boylston, Mass.	7	10,796 95	10,206 50*	Meskill Bros. & Leahy, Everett, Mass.
5	246	Section 3 of relocation of Central Massachusetts Railroad, Clinton, Mass.	-‡	-‡	-‡	Nawn & Brock, Boston, Mass.
6	247	Section 4 of relocation of Central Massachusetts Railroad, West Boylston, Mass.	7	51,561 00	50,772 25*	George M. Atkins & Co., Palmer, Mass.
7	257	Excavating soil from Section 10 of the Wachusett Reservoir in Boylston and West Boylston, Mass.	6	449,300 00	414,987 50*	Bruno, Salomone & Petitti, Boston, Mass.
		Total, ...	. .	. . .	. . .	. . . .

* Contract based upon this bid. † Contract completed.

‡ Competitive bids were not received on this contract.

Appendix No. 1.

THE YEAR 1902 — WATER WORKS.

Reservoir Department.

1902 have been given in previous reports.]

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1902.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1902.	
June 13, '99,	Dec. 1, '02,	-	- -	$1,008,000 00	$978,302 48	1
Dec. 12, '99,	July 1, '03,	Sept. 30, '02,	- -	220,003 15	220,003 15	2
Aug. 1, '01,	Nov. 1, '04,	-	- -	360,870 00	181,113 59	3
April 4, '02,	Sept. 1, '02,	Oct. 10, '02,	For earth excavation, $0.25,	9,263 95	9,263 95	4
May 6, '02,	Jan. 1, '03,	-	For earth excavation, $0.24 per cu. yd.; rock excavation, $1.50 per cu. yd.; soil deposited in embankments, $0.15 additional; broken stone or screened gravel in place, $1 per cu. yd.; Portland cement concrete masonry, $6 per cu. yd.; dimension stone masonry, $15 and $20 per cu. yd.	38,777 60	24,860 10	5
June 5, '02,	April 20, '03,	-	For earth excavation, $0.28 per cu. yd.; slope paving, $2.60 per cu. yd.; riprap, $1 per cu. yd.	50,772 25	36,564 94	6
Dec. 27, '02,	Nov. 1, '05,	-	For clearing and grubbing, $100 per acre; soil excavation, $0.265, $0.30 and $0.34 per cu. yd.; earth excavation, $0.34 per cu. yd.; rock excavation, $1.70 per cu. yd.; paving, $1.90 and $1.75 per cu. yd.; Portland cement concrete masonry, $7 per cu. yd.	414,987 50	-	7
. . .	. . .	. . .	. . . . . .	$2,102,674 45	$1,450,108 21	

CONTRACTS MADE AND PENDING DURING THE

Contracts relating to the

	1. Number of Contract.	2. WORK.	3. Number of Bids.	Amount of Bid. 4. Next to Lowest.	5. Lowest.	6. Contractor.
1	195	Wachusett Dam, . .	11	$1,680,870 00	$1,603,635 00*	McArthur Bros. Company.
2	223†	78 tons special castings, .	2	7,416 65	6,651 56*	Camden Iron Works, .
3	243†	Bronze grooves for Wachusett Dam.	-‡	-‡	-‡	The Wm. Cramp & Sons Ship and Engine Building Company, Philadelphia, Pa.
4	244	Section 1 of relocation of Central Massachusetts Railroad, Berlin and Clinton, Mass.	12	37,691 25	36,767 50*	Crary Construction Company, New York, N. Y.
5	245	Section 2 of relocation of Central Massachusetts Railroad, Clinton, Mass. (extension of Contract No. 195).	-‡	-‡	-‡	McArthur Bros. Company.
6	252	Steel bridges on the relocation of the Central Massachusetts Division of Boston & Maine Railroad, Berlin and Clinton, Mass.	3	94,500 00	91,450 00*	American Bridge Company of New York, New York, N. Y.
7	Special Order.†	Furnishing 8 24-inch and 4 48-inch hydraulic lift valves and 4 48-inch screw lift valves.	2	16,528 00	14,512 00*	Chapman Valve Manufacturing Company.
8	Special Order.†	13.5 tons special castings,	1	-	1,014 00*	Taunton Locomotive Manufacturing Company.
		Total, ...	. .	. . .	. . .	. . . .

Contracts relating to the

9	214†	Excavating mud and earth from Snake Brook Meadow.	8	$17,225 00	$16,850 00*	Long & Little, . .
10	238	Excavating mud and earth from Pegan Brook Meadow in Natick, building embankments and facing them with gravel.	4	42,790 00	35,810 00*	Auguste Saucier, South Framingham, Mass.
		Total, ...	. .	. . .	. . .	. . . .

* Contract based upon this bid. † Contract completed.

‡ Competitive bids were not received on this contract.

YEAR 1902 — WATER WORKS — *Continued.*

Dam and Aqueduct Department.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1902.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1902.	
Oct. 1, '00,	Nov. 15, '04,	-	- -	$1,603,635 00	$555,550 00	1
Nov. 25, '01,	June 1, '02,	Dec. 2, '02,	- -	7,848 78	7,848 78	2
July 3, '02,	Oct. 1, '02,	Oct. 2, '02,	For whole work, $3,660, .	3,660 00	3,660 00	3
May 26, '02,	Dec. 15, '02,	-	For earth excavation, $0.32 per cu. yd.; borrowed earth, $0.30 per cu. yd.; rock excavation, $1 per cu. yd.; Portland cement concrete masonry, $7.50 and $5.50 per cu. yd.; split stone masonry, $13.50 per cu. yd.; dimension stone masonry, $20 per cu. yd.	36,767 60	29,570 00	4
April 18, '02,	April 18, '03,	-	For rock excavation, $1.50 per cu. yd.; rock excavated and disposed of as riprap, $2 per cu. yd.; tunnel excavation, $5 per cu. yd.; Portland cement concrete masonry, in tunnel, $7 and $6 per cu. yd.	236,621 00	118,300 00	5
July 23, '02,	April 1, '03,	-	For whole work, $91,450, .	91,450 00	-	6
Nov. 27, '01,	April 15, '02,	Aug. 5, '02,	- -	14,512 00	14,512 00	7
Dec. 14, '01,	April 15, '02,	May 7, '02,	- -	1,203 37	1,203 37	8
. . .	. . .	. . .	. . . .	$1,995,697 65	$730,644 15	

Sudbury Department.

Sept. 11, '01,	Dec. 15, '01,	Feb. 7, '02,	- -	$14,196 49	$14,196 49	9
May 8, '02,	Dec. 1, '02,	-	For mud excavation, $0.22¾ per cu. yd.; gravel excavation, $0.36 per cu. yd.	46,460 96	46,460 96	10
. . .	. . .	. . .	. . . .	$60,657 45	$60,657 45	

CONTRACTS MADE AND PENDING DURING THE

Contracts relating to the

	1. Number of Contract.	2. WORK.	3. Number of Bids.	Amount of Bid. 4. Next to Lowest.	5. Lowest.	6. Contractor.
1	199	Section 2, Weston Aqueduct.	8	$234,581 50	$200,477 00*	Shanahan, Casparis & Co.
2	200	Section 3, Weston Aqueduct.	9	131,226 10	127,507 50*	Shanahan, Casparis & Co.
3	201†	Section 4, Weston Aqueduct.	19	68,810 50	64,888 50*	Patrick McGovern,
4	202	Section 5, Weston Aqueduct.	16	139,023 00	137,526 50*	Bruno, Salomone & Petitti.
5	203	Section 6, Weston Aqueduct.	14	121,497 00	120,646 50*	Shanahan, Casparis & Co.
6	204	Section 12, Weston Aqueduct.	16	139,197 50	134,096 50*	Shanahan, Casparis & Co.
7	205	Section 13, Weston Aqueduct.	9	364,884 00	346,290 00*	Michael H. Keefe assigned on Oct. 12, 1901, to Columbus Construction Company.
8	208†	Castings for siphon chamber.	4	11,340 00	10,908 00*	Henry R. Worthington,
9	211	Sections 8 and 10, Weston Aqueduct.	11	155,508 50	146,139 00*	Winston & Co.,
10	212	Section 11, Weston Aqueduct.	10	157,270 00	148,635 00*	Winston & Co.,
11	213	Section 15, Weston Aqueduct.	5	197,556 00	171,645 00*	Winston & Co.,
12	218	Section 14, Weston Aqueduct (open channel and upper portion of reservoir).	10	68,364 00	58,490 00*	Nawn & Brock,
13	219	Section 1 of the Weston Reservoir (central portion).	11	64,971 25	59,587 50*	Nawn & Brock,
14	220	Section 2 of the Weston Reservoir (lower portion of reservoir, including dam and concrete drain).	9	90,152 50	88,292 50*	Nawn & Brock,
15	224	2 60-inch Venturi meters,	-‡	-‡	-‡	Builders Iron Foundry, Providence, R. I.
16	226†	34 tons special castings,	5	2,339 10	2,235 70*	Camden Iron Works, Camden, N. J.
17	228	Sections 7 and 9, Weston Aqueduct, riveted steel pipe line 7½ feet in diameter, including an arch of the pipe of about 80 feet span, with masonry abutments, across the Sudbury River in Framingham and Wayland, Mass.	4	147,788 00	134,990 00*	Edward Kendall & Sons, Cambridgeport, Mass.

* Contract based upon this bid. † Contract completed.

‡ Competitive bids were not received on this contract.

YEAR 1902 — WATER WORKS — *Continued.*

Weston Aqueduct Department.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1902.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1902.	
May 9, '01,	Aug. 1, '03,	-	- -	$200,477 00	$136,500 00	1
May 9, '01,	Aug. 1, '03,	-	- -	127,507 50	88,500 00	2
May 6, '01,	Aug. 1, '03,	Sept. 3, '02,	- -	61,161 69	61,161 69	3
May 8, '01,	Aug. 1, '03,	-	- -	129,300 00	119,300 00	4
May 9, '01,	Aug. 1, '03,	-	- -	112,600 00	78,700 00	5
May 9, '01,	Aug. 1, '03,	-	- -	134,096 50	95,900 00	6
May 20, '01,	Aug. 1, '03,	-	- -	403,000 00	253,800 00	7
May 21, '01,	April 1, '02,	May 29, '02,	- -	11,258 00	11,258 00	8
Aug. 28, '01,	Aug. 1, '03,	-	- -	146,139 00	80,000 00	9
Aug. 28, '01,	Aug. 1, '03,	-	- -	148,635 00	95,000 00	10
Aug. 28, '01,	Aug. 1, '03,	-	- -	171,645 00	97,200 00	11
Nov. 26, '01,	Aug. 1, '03,	-	- -	58,490 00	31,600 00	12
Nov. 26, '01,	Aug. 1, '03,	-	- -	59,587 50	9,900 00	13
Nov. 26, '01,	Aug. 1, '03,	-	- -	88,292 50	38,200 00	14
Jan. 11, '02,	April 26, '02,	-	For whole work, $7,200, .	7,200 00	6,180 00	15
Jan. 30, '02,	July 1, '02,	Aug. 5, '02,	For all castings, $63 per ton of 2,000 lbs.	2,284 84	2,284 84	16
Mar. 8, '02,	July 1, '03,	-	For earth excavation, $0.40 and $0.70 per cu. yd.; furnishing, laying and testing 7½-foot pipe, $21.30 per lin. ft.; Portland cement concrete masonry, $7 and $6 per cu. yd.; stone masonry, $40 per cu yd.	134,990 00	116,400 00	17

CONTRACTS MADE AND PENDING DURING

Contracts relating to the

	1. Number of Contract.	2. WORK.	3. Number of Bids.	Amount of Bid. 4. Next to Lowest.	5. Lowest.	6. Contractor.
1	236†	Distribution of 60-inch cast-iron water pipes and special castings, Southborough, Mass.	-‡	-‡	-‡	L. F. Childs, Framingham, Mass.
2	241†	Cast-iron columns and grooves.	5	$2,905 00	$2,780 10*	Davis & Farnum Manufacturing Company, Waltham, Mass.
3	242†	Steel work for chambers, .	4	3,212 00	3,000 00*	G. W. & F. Smith Iron Company, Boston, Mass.
4	250	Section 1, Weston Aqueduct, laying 3 60-inch cast-iron pipe lines, each about 480 feet long, including special castings and outlet branches; a 48-inch cast-iron pipe line about 275 ft. long; building outlet and head chambers and an arch bridge of 30 ft. span, Southborough, Mass.	10	32,110 00	29,030 00*	T. H. Gill & Co., Somerville, Mass.
5	256†	Blow-off for steel pipe siphon on Section 9, Weston Aqueduct, Wayland, Mass.	4	2,351 25	2,306 25*	T. Bruno, Boston, Mass.
6	258	Superstructures of 4 siphon and 2 gaging chambers of the Weston Aqueduct, Framingham and Wayland, Mass.	7	29,315 00	27,352 00*	The Norcross Bros. Company, Boston, Mass.
		Total, ...	. .	. . .	. . .	. . . .

Contracts relating to the

7	206†	Masonry water tower on Forbes Hill, Quincy, Mass.	4	$24,973 00	$24,790 00*	J. E. McCoy, . . .
8	209†	Bear Hill Reservoir in Stoneham, Mass.	6	19,456 00*	16,950 00	The C. H. Eglee Company.

* Contract based upon this bid. † Contract completed.

‡ Competitive bids were not received on this contract.

THE YEAR 1902 — WATER WORKS — *Continued.*

Weston Aqueduct Department — Concluded.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1902.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1902.	
Mar. 20, '02,	-	Dec. 1, '02,	For hauling and distributing 60-inch pipes and special castings, $1.25 per ton of 2,000 lbs.	$1,043 88	$1,043 88	1
April 30, '02,	July 15, '02,	Oct. 2, '02,	Castings for Wachusett Dam, $504.50; for Weston Aqueduct, $2,275.60.	2,712 10	2,712 10	2
April 30, '02,	July 1, '02,	Oct. 2, '02,	Steel work for Wachusett Dam, $230; for Weston Aqueduct, $2,770.	3,000 00	3,000 00	3
June 19, '02,	July 1, '03,	-	For constructing, maintaining and removing temporary works, $800; earth excavation, $0.38 per cu. yd.; rock excavation, $2 per cu. yd.; Portland cement concrete masonry, $6.90 and $6 per cu. yd.; ashlar masonry, $22 per cu. yd.; dimension stone masonry, $40 per cu. yd.; dry rubble stone paving, $4 per cu. yd.; laying and connecting cast-iron pipes and special castings, $1,000.	29,030 00	20,500 00	4
Oct. 30, '02,	Dec. 1, '02,	Dec. 1, '02,	For laying 12-inch cast-iron pipe and 24-inch vitrified clay pipe, including excavation of trench, $1.25 per lin. ft.; earth excavation from open ditch, $0.65 per cu. yd.; dry rubble paving, $2 per cu. yd.; riprap, $1.50 per cu. yd.	2,191 94	2,191 94	5
Dec. 18, '02,	Aug. 1, '03,	-	For each of the siphon chambers numbered 1 and 2, $4,573; numbered 3 and 4, $5,522; for gaging chambers, $3,360 and $3,802.	27,352 00	-	6
. . .	. . .	. . .	. . . .	$2,061,994 45	$1,351,332 45	

Distribution Department.

May 23, '01,	Nov. 1, '01,	Dec. 12, '02,	- -	$25,967 95	$25,967 95	7
July 16, '01,	Nov. 15, '01,	July 14, '02,	- -	24,894 47	24,894 47	8

CONTRACTS MADE AND PENDING DURING

Contracts relating to the

	1. Number of Contract.	2. WORK.	3. Number of Bids.	AMOUNT OF BID. 4. Next to Lowest.	5. Lowest.	6. Contractor.
1	216	9,120 tons cast-iron water pipes, 7,800 tons 48-inch, 1,320 tons 60-inch, 100 tons special castings.	2	48-inch pipes, $25.80 per ton; special castings, $60 per ton.	48-inch pipes, $22.87 per ton; special castings, $59 per ton.*	United States Cast Iron Pipe and Foundry Company.
2	217†	9,300 tons cast-iron water pipes, 5,800 tons 48-inch, 3,500 tons 60-inch, 100 tons special castings.§	-‡	-‡	48-inch pipes, $23.87 per ton; 60-inch pipes, $26.90 per ton; special castings, $75 per ton.*	United States Cast Iron Pipe and Foundry Company.
3	221†	39 water valves, 10 36-inch, 8 24-inch, 6 16-inch, 15 12-inch.	4	$12,650 00	$11,940 00*	Geo. F. Blake Manufacturing Company.
4	222	284 tons special castings,§	2	23,727 64	22,894 25*	Geo. F. Blake Manufacturing Company.
5	225†	17 tons special castings for Wachusett Dam and Weston Aqueduct.	4	1,138 50	847 50*	Davis & Farnum Manufacturing Company, Waltham, Mass.
6	227	Drain valves, sluice gates, steel work and Coffin ball-bearing gate stands.	Lot 1-2, Lot 2-3, Lot 3,‡	3,380 00 253 00 -‡	2,061 00* 220 00* -‡	Coffin Valve Company, Boston, Mass.
7	230	250 tons special castings, .	3	19,370 00	15,500 00*	Camden Iron Works, Camden, N. J.
8	231†	Laying water pipes in Medford, Section 12 of the distribution system.	7	36,654 50	36,245 00*	C. E. Trumbull & Co., Boston, Mass.
9	232†	120 cast-iron frames and covers.	5	875 00	850 00*	Osgood & Witherly, Somerville, Mass.
10	233†	400 tons cast-iron water pipes, 5 tons special castings.	3	10,505 00	10,405 00*	United States Cast Iron Pipe and Foundry Company, New York, N. Y.
11	234†	16 sets steel work for covering valve chambers.	3	1,152 00	1,056 00*	New England Structural Company, Boston, Mass.

* Contract based upon this bid. † Contract completed.

‡ Competitive bids were not received on this contract.

§ Includes pipes and castings supplied to other departments.

THE YEAR 1902 — WATER WORKS — *Continued.*

Distribution Department — Continued.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1902.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1902.	
Nov. 21, '01,	Dec. 1, '02,	-	NOTE. — After bids were received for contracts 216 and 217 the amount of pipe to be furnished was increased at the prices bid before making the contracts. At a subsequent date contract No. 216 was further extended by the addition of 220 tons of 60-inch pipes at $28.90 per ton, and contract No. 217 was increased by the addition of 140 tons 60-inch and 210 tons 48-inch pipe at the prices bid.	$213,876 00	$212,270 90	1
Nov. 21, '01,	Dec. 1, '02,	Nov. 12, '02,		242,236 53	242,236 53	2
Nov. 30, '01,	Aug. 30, '02,	Dec. 19, '02,	- -	11,940 00	11,940 00	3
Nov. 25, '01,	Sept. 1, '02,	-	NOTE. — To obtain the castings called for by this contract at the required time, portions of them were obtained under contracts Nos. 260 and 261.	18,120 92	18,082 72	4
Jan. 30, '02,	May 1, '02,	June 11, '02,	For curves, flanged pipes and platform supports, $50 per ton of 2,000 lbs.; double branches, curves and special bell pipes, $65 per ton of 2,000 lbs.	934 95	934 95	5
Jan. 24, '02,	-	-	Lot 1, 11 drain valves and 4 sluice gates, $2,061; Lot 2, steel work, $220; Lot 3, 4 Coffin ball-bearing gate stands, $1,560.	3,841 00	3,741 00	6
Mar. 6, '02,	Dec. 1, '02,	-	For all castings, $62 per ton of 2,000 lbs.	15,500 00	13,685 11	7
April 3, '02,	Oct. 1, '02,	Dec. 1, '02,	For laying 48-inch cast-iron pipes, $2.60 per lin. ft.; rock excavation, $2 per cu. yd.; brick chambers for valves, $75 and $50 each; concrete masonry, $7 per cu. yd.	44,431 59	44,431 59	8
Mar. 11, '02,	June 11, '02,	Dec. 15, '02,	For castings, $.017 per lb., .	1,136 91	1,136 91	9
Mar. 10, '02,	July 1, '02,	July 15, '02,	For 12-inch cast-iron pipe, $25.40; special castings, $49 per ton of 2,000 lbs.	10,702 64	10,702 64	10
Mar. 11, '02,	Aug. 11, '02,	July 25, '02,	For steel work for covering valve chambers, $66 per set.	1,056 00	1,056 00	11

CONTRACTS MADE AND PENDING DURING

Contracts relating to the

	1. Number of Contract.	2. WORK.	3. Number of Bids.	AMOUNT OF BID. 4. Next to Lowest.	5. Lowest.	6. Contractor.
1	235	Laying water pipes in Newton, Section 2 of the supply pipe lines.	6	$53,121 75	$50,976 00*	D. F. O'Connell, Boston, Mass.
2	237	Laying water pipes in Brighton and Newton, Section 4 of the supply pipe lines.	7	34,430 00	28,363 00*	Thomas F. Moore, Syracuse, N. Y.
3	239†	Laying water pipes in Hyde Park, Section 30 of the distribution system.	4	8,243 25	7,882 15*	T. Bruno, Boston, Mass.
4	240	Laying water pipes in Medford.	7	60,255 00	52,925 00*	Coleman Bros., Everett, Mass.
5	248†	60 tons special castings, .	3	3,120 00	3,000 00*	Warren Foundry and Machine Company, Phillipsburg, N. J.
6	249†	45 water valves and 3 sluice gates.	-‡	-‡	-‡	Coffin Valve Company, Boston, Mass.
7	251	Laying water pipes in Newton and Weston, including crossing of Charles River.	6	34,155 00	33,564 00*	Ward & Cummings, Boston, Mass.

* Contract based upon this bid. † Contract completed.
‡ Competitive bids were not received on this contract.

THE YEAR 1902 — WATER WORKS — *Continued.*

Distribution Department — Continued.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1902.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1902.	
April 7, '02,	Dec. 1, '02,	–	For laying cast-iron pipes: 48-inch, \$2.21, 36-inch, \$2 per lin. ft.; rock excavation, \$3.50 and \$5 per cu. yd.; earth excavation, \$1 and \$0.65 per cu. yd.; setting air valves, \$5 each; chambers for valves, blow-offs, etc., \$75 and \$30; laying sewer pipe for drains: 8-inch, \$0.37, 10-inch, \$0.39, 12-inch, \$0.45, 15-inch, \$0.50, 18-inch, \$0.65, 20-inch, \$1 per lin. ft.; man-holes and catch-basins for drains, \$30 and \$45, respectively; concrete masonry, \$5 per cu. yd.	\$71,000 00	\$70,100 00	1
April 18, '02,	Nov. 1, '02,	–	For laying 48-inch cast-iron pipes, \$2.19 per lin. ft.; rock excavation, \$2.50 and \$6 per cu. yd.; earth excavation, \$0.50 per cu. yd; chambers for valves, blow-offs, etc., \$62 and \$34; concrete masonry, \$5.25 per cu. yd.	28,363 00	26,600 00	2
April 28, '02,	July 15, '02,	Sept. 17, '02,	For laying cast-iron pipes: 12-inch, \$0.53, 12-inch with flexible joint, \$9 per lin. ft.; rock excavation, \$4 and \$5 per cu. yd.; brick chambers for valves, \$45; concrete masonry, \$8 per cu. yd.	7,602 81	7,602 81	3
May 2, '02,	Dec. 15, '02,	–	For earth excavation, \$0.50 per cu. yd.; rock excavation, \$2 per cu. yd.; laying 60-inch cast-iron water pipes, \$3.50 per lin. ft.; chambers for blow-offs and valves, \$100; concrete masonry, \$6 per cu. yd.	57,500 00	56,700 00	4
May 19, '02,	Oct. 15, '02,	Oct. 15, '02,	For castings, \$50 per ton of 2,000 lbs.	2,901 30	2,901 30	
May 19, '02,	Nov. 1, '02,	Dec. 26, '02,	For valves: 12-inch, \$121; 16-inch, \$160. For sluice gates with wall plates: 30-inch, \$415; 12-inch, \$150.	7,205 00	7,205 00	6
July 26, '02,	June 15, '03,	–	For building and maintaining coffer-dam and pumping and draining, \$14,887. For laying cast-iron water pipes: 60-inch, \$3.25 and \$4.85, 48-inch, \$3, 36-inch, \$2.90 per lin. ft.; rock excavation, \$4 per cu. yd.; earth excavation, \$0.80 per cu. yd.; chambers for valves, blow-offs, etc., \$98 and \$65; concrete masonry, \$7 per cu. yd.	33,564 00	24,300 00	7

CONTRACTS MADE AND PENDING DURING

Contracts relating to the

	1. Number of Contract.	2. WORK.	3. Number of Bids.	AMOUNT OF BID. 4. Next to Lowest.	AMOUNT OF BID. 5. Lowest.	6. Contractor.
1	253	42 Venturi meter tubes with registers and chart recorders.	-‡	-‡	-‡	Builders Iron Foundry, Providence, R. I.
2	254†	15 12-inch and 6 16-inch water valves.	-‡	-‡	-‡	Coffin Valve Company, Boston, Mass.
3	255†	35 steel chambers for Venturi meter registers.	4	$8,050 00	$6,125 00*	Daniel Russell Boiler Works, Boston, Mass.
4	260†	70,830 lbs. special castings,	-‡	-‡	-‡	United States Cast Iron Pipe and Foundry Company, Philadelphia, Pa.
5	261†	44,610 lbs. special castings,	-‡	-‡	-‡	Taunton Locomotive Manufacturing Company, Taunton, Mass.
6	4-M	2 vertical fire-tube boilers,	4	12,880 00	12,500 00*	The I. P. Morris Company, Philadelphia, Pa.
7	5-M	Excavating material and building a trestle and coffer-dam at the Mystic River, Somerville.	-‡	-‡	-‡	Lawler Bros., Boston, Mass.
8	Special Order.†	50 tons cast-iron water pipes, 9,600 lbs. special castings at Berlin and Wayland.	3	Pipes, $24.90 per ton; special castings, $52 per ton.	Pipes, $24.40 per ton; special castings $54.40 per ton.*	United States Cast Iron Pipe and Foundry Company, Phillipsburg, N. J.
9	Special Order.†	43 tons 16-inch pipe, . .	3	$25.90 per ton.	$25.80 per ton.*	Camden Iron Works, Camden, N. J.
		Totals, ...	. .	. . . .	. . .	. . . .

* Contract based upon this bid. † Contract completed.
‡ Competitive bids were not received on this contract.

THE YEAR 1902 — WATER WORKS — *Continued.*

Distribution Department — Concluded.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1902.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1902.	
June 20, '02,	-	-	For 8-inch, $527.85, 10-inch, $550.80, 12-inch, $581.40, 16-inch, $650.25, 20-inch, $742.05, 24-inch, $856.80, 30-inch, $1,063.35, 48-inch, $2,279.70 each.	$31,158 45	$12,078 95	1
Feb. 14, '02,	-	Nov. 12, '02,	For 12-inch valves, $121; 16-inch valves, $158.	2,763 00	2,763 00	2
Aug. 4, '02,	Nov. 1, '02,	Dec. 9, '02,	For each chamber, $175, .	6,942 81	6,942 81	3
Aug. 6, '02,	Sept. 6, '02,	Nov. 24, '02,	NOTE. — Contracts Nos. 260 and 261 were made to provide castings which were not furnished at the required time under contract No. 222.	3,752 80	3,752 80	4
Aug. 7, '02,	-	Oct. 29, '02,	- - -	1,891 58	1,891 58	5
Feb. 24, '02,	June 30, '02,	-	For each boiler, $6,250, .	12,500 00	11,400 00	6
Sept. 26, '02,	Dec. 1, '02,	-	For whole work, $3,600, .	3,694 39	3,694 39	7
Jan. 23, '02,	-	May 15, '02,	For cast-iron pipes, $24.40; special castings, $54.40 per ton of 2,000 lbs.	1,514 80	1,514 80	8
Feb. 25, '02,	May 1, '02,	Mar. 22, '02,	For cast-iron pipes, $25.80 per ton of 2,000 lbs.	1,106 30	1,106 30	9
. . .	. . .	. . .	. . . .	$888,099 20	$851,634 51	

Contracts made and pending during the Year 1902 — Water Works — *Concluded.*

Summary of Contracts.*

	Approximate Amount of Contracts.	Value of Work done December 31, 1902.
Wachusett Reservoir, 5 contracts,	$2,013,124 60	$1,388,683 17
Relocation of Central Massachusetts Railroad, 5 contracts,	454,388 35	209,295 04
Wachusett Dam, 3 contracts,	1,615,143 78	567,058 78
Sudbury Department, 2 contracts,	60,657 45	60,657 45
Weston Aqueduct and Reservoir, 23 contracts,	2,061,994 45	1,351,332 45
Distribution Department, 25 contracts,	869,283 71	833,919 02
Total of 63 contracts made and pending during the year 1902,	$7,074,592 34	$4,410,945 91
203 contracts completed in 1896, 1897, 1898, 1899, 1900 and 1901,	7,654,798 39	7,654,798 39
	$14,729,390 73	$12,065,744 30
Deduct for work done on 11 Sudbury Reservoir contracts by the city of Boston,	512,000 00	512,000 00
Total of 266 contracts,	$14,217,390 73	$11,553,744 30

* In this summary, contracts charged to maintenance are excluded.

Appendix No. 2.

Cement Tests — Water Works.

The following tables contain: —

1. Long-time tests of cements used by the Dam and Aqueduct and Reservoir departments during the years 1896 to 1900, inclusive. The tests for shorter periods were published in Appendix No. 3 of the annual report for the year 1900.

2. All tests of cements used in the construction of the Wachusett Dam during the years 1901 and 1902, including that used on the relocation of the Central Massachusetts Railroad during the year 1902.

3. Tests of all cements used in the construction of the Weston Aqueduct during the years 1901 and 1902.

The methods of testing were the same as described in Appendix No. 3 of the annual report for the year 1897.

Tabulation of Cement Tests for All Brands of Natural Cement, of which Nine Hundred Barrels or More were used on Construction Work by the Dam and Aqueduct and Reservoir Departments from 1896 to 1900, Inclusive.

BRAND.	Number of Barrels used.	Composition of Briquette.	Tensile Strength.					
			Two Years.		Three Years.		Five Years.	
			Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.
Beach,	8,380	Neat,	64	467	50	482	23	506
		1 to 1,	64	316	50	349	24	369
Hoffman,	45,345	Neat,	106	467	91	495	45	512
		1 to 1,	106	327	91	347	45	359
Norton,	60,877	Neat,	60	440	54	456	28	479
		1 to 1,	60	295	54	314	27	325
Union,	900	Neat,	22	409	10	474	4	476
		1 to 1,	22	570	10	617	4	576
Totals,	115,502	Neat,	252	456	205	480	100	500
		1 to 1,	252	338	205	352	100	361

Tabulation of Cement Tests for All Brands of Portland Cement, of which Nine Hundred Barrels or More were used on Construction Work by the Dam and Aqueduct and Reservoir Departments from 1896 to 1900, Inclusive.

BRAND.	Number of Barrels used.	Composition of Briquette.	Tensile Strength. Eighteen Months. Number of Briquettes.	Tensile Strength. Eighteen Months. Pounds per Square Inch.	Tensile Strength. Two Years. Number of Briquettes.	Tensile Strength. Two Years. Pounds per Square Inch.	Tensile Strength. Three Years. Number of Briquettes.	Tensile Strength. Three Years. Pounds per Square Inch.	Tensile Strength. Five Years. Number of Briquettes.	Tensile Strength. Five Years. Pounds per Square Inch.
Atlas,	18,509	Neat,	65	848	80	813	64	814	26	782
		2 to 1,	65	324	80	325	64	336	26	322
Brooks-Shoobridge,	5,706	Neat,	5	674	55	702	53	696	27	679
		2 to 1,	5	521	55	447	53	449	27	453
Giant,	15,394	Neat,	55	598	55	622	45	618	12	614
		2 to 1,	55	426	55	422	45	414	12	435
Iron Clad,	7,778	Neat,	34	769	34	800	26	826	6	736
		2 to 1,	34	396	34	394	26	378	6	394
Stettin-Girstow,	979	Neat,	8	665	51	714	42	709	22	695
		2 to 1,	8	370	53	340	42	332	21	300
West Kent,	3,394	Neat,	19	586	59	589	51	570	29	562
		2 to 1,	19	522	59	434	51	424	26	391
Totals,	51,760	Neat,	186	721	334	707	281	701	122	673
		2 to 1,	186	395	336	389	281	389	118	378

Tabulation of Cement Tests of Cement used in the Construction of the Wachusett Dam in 1901 and 1902, including that used on the Central Massachusetts Railroad Relocation in 1902.

BRAND.	Number of Barrels used.			Composition of Briquette.	Fineness.			Wire Tests.	
	Dam.	Railroad.	Totals.		Per Cent. Residue on No. 50 Sieve, 2,500 Meshes to Square Inch.	Per Cent. Residue on No. 100 Sieve, 10,000 Meshes to Square Inch.	Per Cent. Residue on No. 180 Sieve, 32,400 Meshes to Square Inch.	Minutes to Bear Light Wire.	Minutes to Bear Heavy Wire.
Alpha (Portland),	150	341	491	Neat,	.4	10.9	28.6	158	347
				2 to 1,	-	-	-	-	316
Alsen (Portland),	225	62	287	Neat,	.4	11.2	26.4	116	291
				2 to 1,	-	-	-	-	306
Atlas (Portland),	2,894	623	3,517	Neat,	.2	9.2	22.6	110	348
				2 to 1,	-	-	-	-	278
Giant (Portland),	31,839	1,308	33,147	Neat,	.6	9.9	23.7	117	349
				2 to 1,	-	-	-	-	347
Helderberg (Portland),	200	12	212	Neat,	.2	5.0	19.9	173	480
				2 to 1,	-	-	-	-	450
Iron Clad (Portland),	4,260	280	4,540	Neat,	.1	4.2	17.1	86	304
				2 to 1,	-	-	-	-	293
Lehigh (Portland),	-	984	984	Neat,	.5	10.9	25.1	153	418
				2 to 1,	-	-	-	-	418
Stettin-Girstow (Portland),	-*	-	-	Neat,	.7	8.3	21.3	62	178
				2 to 1,	-	-	-	-	351
Totals,	39,568	3,610	43,178	Neat,	.5	9.2	22.9	112	337
				2 to 1,	-	-	-	-	338
Union (natural),	61,788	-	-	Neat,	1.0	6.4	14.2	89	186
				1 to 1,	-	-	-	75	150
				2 to 1,	-	-	-	-	-

* 2,692 barrels tested but not used in 1902.

Tabulation of Cement Tests of Cement used in the Construction of the Wachusett Dam in 1901 and 1902, including that used on the Central Massachusetts Railroad Relocation in 1902 — Concluded.

BRAND.	Number of Barrels used.	Composition of Briquette.	Tensile Strength. One Day. Number of Briquettes.	One Day. Pounds per Square Inch.	Seven Days. Number of Briquettes.	Seven Days. Pounds per Square Inch.	Twenty-eight Days. Number of Briquettes.	Twenty-eight Days. Pounds per Square Inch.	Three Months. Number of Briquettes.	Three Months. Pounds per Square Inch.	Six Months. Number of Briquettes.	Six Months. Pounds per Square Inch.	Nine Months. Number of Briquettes.	Nine Months. Pounds per Square Inch.	One Year. Number of Briquettes.	One Year. Pounds per Square Inch.	Eighteen Months. Number of Briquettes.	Eighteen Months. Pounds per Square Inch.
Alpha (Portland),	491	Neat,	47	694	47	1,021	5	1,026	5	1,029	-	-	-	-	-	-	-	-
		2 to 1,	-	-	47	474	5	428	5	445	-	-	-	-	-	-	-	-
Alsen (Portland),	287	Neat,	31	625	32	776	15	753	5	761	-	-	-	-	-	-	-	-
		2 to 1,	-	-	32	373	15	433	5	413	-	-	-	-	-	-	-	-
Atlas (Portland),	3,517	Neat,	188	578	187	841	143	851	15	803	-	-	-	-	-	-	-	-
		2 to 1,	-	-	188	385	143	445	15	450	-	-	-	-	-	-	-	-
Giant (Portland),	33,147	Neat,	2,271	603	2,213	836	1,991	880	125	861	110	908	100	887	100	889	20	916
		2 to 1,	-	-	2,273	400	1,990	445	125	445	110	429	100	426	95	420	20	331
Helderberg (Portland),	212	Neat,	23	383	23	843	23	933	-	-	-	-	-	-	-	-	-	-
		2 to 1,	-	-	23	301	23	409	-	-	-	-	-	-	-	-	-	-
Iron Clad (Portland),	4,540	Neat,	222	652	218	700	221	712	20	704	10	752	-	-	-	-	-	-
		2 to 1,	-	-	218	403	222	451	20	472	10	485	-	-	-	-	-	-
Lehigh (Portland),	984	Neat,	90	553	90	893	5	841	5	904	-	-	-	-	-	-	-	-
		2 to 1,	-	-	90	426	5	409	5	435	-	-	-	-	-	-	-	-
Stettin-Girstow (Portland),	-*	Neat,	252	377	166	466	92	510	-	-	-	-	-	-	-	-	-	-
		2 to 1,	-	-	166	277	92	375	-	-	-	-	-	-	-	-	-	-
Totals,	43,178	Neat,	3,124	585	2,976	809	2,495	850	175	841	120	895	100	887	100	889	20	916
		2 to 1,	-	-	3,037	394	2,495	442	175	447	120	434	100	426	95	420	20	331
Union (natural),	61,788	Neat,	2,860	171	2,854	227	1,688	301	165	355	125	407	-	-	65	433	-	-
		1 to 1,	-	-	2,854	184	1,686	279	165	414	125	502	-	-	65	569	-	-
		2 to 1,	-	-	449	103	443	179	105	217	45	331	-	-	-	-	-	-

* 2,602 barrels tested but not used in 1902.

Tabulation of Cement Tests for All Brands of Natural and Portland Cement used in Construction of the Weston Aqueduct during 1901 and 1902.

BRAND.	Number of Barrels used.	Composition of Briquette.	Fineness. Per Cent. Residue on No. 50 Sieve, 2,500 Meshes to Square Inch.	Fineness. Per Cent. Residue on No. 100 Sieve, 10,000 Meshes to Square Inch.	Fineness. Per Cent. Residue on No. 180 Sieve, 32,400 Meshes to Square Inch.	Wire Tests. Minutes to bear Light Wire.	Wire Tests. Minutes to bear Heavy Wire.	Tensile Strength. One Day. Number of Briquettes.	One Day. Pounds per Square Inch.	Seven Days. Number of Briquettes.	Seven Days. Pounds per Square Inch.	Twenty-eight Days. Number of Briquettes.	Twenty-eight Days. Pounds per Square Inch.	Three Months. Number of Briquettes.	Three Months. Pounds per Square Inch.	Six Months. Number of Briquettes.	Six Months. Pounds per Square Inch.	One Year. Number of Briquettes.	One Year. Pounds per Square Inch
Natural cements:—																			
Hoffman, . .	67,347	Neat, .	1.3	7.6	–	22	49	3,582	152	3,579	173	1,838	274	154	327	74	372	54	373
		1 to 1, .	–	–	–	19	48	–	–	3,512	141	1,832	261	169	324	77	384	53	320
Union, . . .	14,338	Neat, .	1.0	6.8	13.2	40	90	820	158	821	206	404	270	46	314	37	354	23	268
		1 to 1, .	–	–	–	27	73	–	–	821	175	421	248	49	359	36	385	20	444
Totals, . .	81,685	Neat, .	1.3	7.4	–	25	50	4,402	153	4,400	179	2,242	273	200	324	111	366	77	342
		1 to 1, .	–	–	–	20	52	–	–	4,333	147	2,253	258	218	332	113	384	73	354
Portland cements:—																			
Atlas, . . .	48,850	Neat, .	.2	9.4	20.2	49	297	2,601	482	[illegible]	708	809	765	188	773	124	775	105	737
		2 to 1, .	–	–	–	–	293	–	–	[illegible]	299	1,670	403	179	450	127	432	109	380
Giant, . . .	7,353	Neat, .	.3	9.4	20.6	67	304	378	433	378	680	186	744	58	792	29	784	19	836
		2 to 1, .	–	–	–	–	366	–	–	364	331	[illegible]	418	57	459	30	402	24	403
Saylors, . .	1,510	Neat, .	.2	7.4	21.6	120	482	98	227	100	740	80	805	34	788	–	–	–	–
		2 to 1, .	–	–	–	–	544	–	–	98	273	79	383	27	387	–	–	–	–
Lehigh, . .	1,710	Neat, .	.2	9.1	22.1	99	282	73	482	73	737	54	769	15	697	–	–	–	–
		2 to 1, .	–	–	–	–	366	–	–	72	380	52	450	19	503	–	–	–	–
Totals, . .	59,423	Neat, .	.2	9.3	20.3	55	302	3,150	408	3,130	706	1,129	764	295	775	153	777	124	752
		2 to 1, .	–	–	–	–	313	–	–	2,942	304	2,059	405	282	449	157	426	133	384

Appendix No. 3.

Table No. 1. — *Monthly Rainfall in Inches at Various Places on the Metropolitan Water Works, in 1902.*

PLACE.		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
Nashua Watershed.	Princeton,	3.10	4.20	4.84	4.43	2.98	3.09	3.96	3.62	4.30	6.56	0.92	7.39	49.39
	Jefferson,	2.96	5.01	5.36	4.01	1.60	2.44	3.96	5.50	4.18	6.76	0.95	7.21	49.94
	Sterling,	2.30	4.72	5.12	4.37	2.61	2.51	4.16	3.01	3.72	6.38	0.76	7.00	46.66
	Boylston,	2.50	5.70	5.78	4.61	1.79	2.01	3.41	3.67	4.84	5.72	1.11	7.19	48.33
Sudbury Watershed.	Sudbury Dam,	2.45	6.01	4.71	3.84	1.93	2.91	3.04	3.72	4.40	4.37	1.44	5.80	44.62
	Framingham,	2.71	6.65	6.45	4.62	1.79	2.42	2.97	4.07	4.34	4.20	1.36	6.61	48.19
	Ashland Dam,	2.34	6.34	4.72	3.79	1.62	3.25	3.05	2.79	3.99	4.32	1.43	6.32	43.96
	Cordaville,	2.56	5.72	5.48	4.26	2.09	3.00	2.68	3.04	5.44	4.86	1.59	6.78	47.50
Lake Cochituate,		2.11	6.67	5.04	3.66	1.24	2.42	3.53	3.39	4.91	4.05	1.37	6.22	44.61
Chestnut Hill Reservoir,		1.98	7.76	5.27	3.97	1.11	2.74	3.52	2.96	3.31	4.64	1.56	5.43	44.25
Spot Pond,		2.22	7.56	4.90	4.70	1.15	2.33	2.76	3.80	3.44	4.72	1.33	5.86	44.77
Averages of all,		2.48	6.03	5.24	4.20	1.81	2.65	3.37	3.60	4.26	5.14	1.26	6.53	46.57
Averages, Nashua watershed,		2.72	4.91	5.27	4.36	2.24	2.51	3.87	3.95	4.26	6.36	0.93	7.20	48.58
Averages, Sudbury watershed,		2.52	6.18	5.34	4.13	1.86	2.89	2.94	3.40	4.54	4.41	1.45	6.38	46.07

TABLE No. 2. — *Rainfall in Inches at Jefferson, Mass., in 1902.*

DAY OF MONTH.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1,	-	*	-	-	-	-	-	-	-	0.52†	-	-
2,	*	0.66§	0.55†	-	-	-	-	-	-	-	-	-
3,	0.20‡	-	-	-	0.12†	0.26†	0.31†	-	-	-	-	0.55§
4,	-	-	-	-	0.07†	-	-	-	0.27†	-	-	-
5,	-	-	1.40‡	-	-	-	0.07†	-	-	*	-	0.75‡
6,	-	-	-	*	-	-	-	0.60†	-	1.91†	0.11†	-
7,	*	-	-	0.09†	-	0.07†	-	-	0.05†	-	-	0.17‡
8,	0.17‡	-	*	*	0.04†	0.18†	-	0.33†	-	-	-	-
9,	-	-	0.95§	*	-	-	-	-	0.82†	-	-	-
10,	0.03‡	-	-	2.09†	-	0.15†	0.35†	-	-	-	-	0.06‡
11,	*	-	-	0.04†	-	-	-	2.23†	-	*	-	0.18‡
12,	0.68‡	-	-	-	-	-	-	-	-	1.12†	*	-
13,	-	-	-	-	0.03†	0.33†	-	-	0.52†	-	0.21†	*
14,	-	-	0.08†	-	-	-	-	-	-	-	-	1.18‡
15,	-	-	-	-	-	0.11†	0.38†	-	-	-	-	-
16,	-	-	*	-	-	0.12†	-	-	-	-	-	*
17,	-	*	1.12†	-	-	-	-	-	-	-	-	1.48‡
18,	-	1.68‡	-	0.02†	-	-	-	*	*	-	-	-
19,	-	-	0.11§	-	0.32†	0.13†	*	0.30†	*	-	-	-
20,	0.04‡	-	*	-	-	-	*	-	*	0.06†	-	-
21,	*	*	0.15†	-	-	0.43†	*	0.04†	0.52†	-	-	*
22,	1.25†	0.66‡	-	-	-	-	2.10†	-	-	0.07†	0.07†	1.93‖
23,	-	-	-	-	-	-	0.68†	-	-	0.08†	-	-
24,	-	-	-	-	-	-	-	-	-	-	-	-
25,	-	*	-	-	0.15†	-	-	0.25†	-	-	-	*
26,	*	*	-	-	0.45†	0.41†	-	-	*	-	*	0.57‡
27,	0.56§	0.56†	-	0.25†	-	-	0.07†	-	*	-	0.43†	0.04‡
28,	-	1.45†	*	-	0.35†	-	-	-	*	3.00†	-	-
29,	-	-	0.97†	*	-	0.14†	-	-	*	-	-	0.30§
30,	0.03‡	-	-	1.52†	0.07†	-	-	1.75†	2.00†	-	0.13†	-
31,	-	-	0.03‡	-	-	0.11†	-	-	-	-	-	-
Totals,	2.96	5.01	5.36	4.01	1.60	2.44	3.96	5.50	4.18	6.76	0.95	7.21

Total for the year, 49.94 inches.

* Rainfall included in that of following day. † Rain. ‡ Snow.
§ Rain and snow. ‖ Rain, snow and hail.

TABLE NO. 3. — *Rainfall in Inches at Framingham, Mass., in 1902.*

DAY OF MONTH.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1,	–	–	–	–	–	–	0.03†	–	0.04†	0.40†	–	–
2,	*	0.84§	0.42†	–	–	–	–	–	–	–	–	*
3,	0.14§	–	–	–	0.07†	0.08†	0.19†	–	–	–	–	0.49†
4,	–	0.01‡	–	–	0.12†	0.01†	–	0.82†	0.21†	–	0.02†	–
5,	–	–	1.45‡	–	–	0.04†	0.05†	–	–	*	–	0.65‡
6,	–	–	–	0.04†	0.10†	–	0.05†	0.32†	–	0.62†	0.04†	–
7	0.11‡	–	–	–	–	0.10†	–	–	0.71†	–	–	0.15‡
8,	–	–	*	–	–	0.18†	0.15†	0.49†	–	–	–	–
9,	–	–	1.24†	–	–	–	–	–	0.67†	–	–	–
10,	0.02‡	–	–	2.12†	–	0.06†	0.35†	–	–	–	–	–
11,	*	–	–	0.03†	–	–	–	1.99†	–	*	–	*
12,	0.45‡	–	–	–	–	–	–	–	–	1.31†	0.13†	0.16‡
13,	–	0.01‡	*	–	0.04†	0.51†	–	–	0.84†	–	0.04†	*
14,	–	–	0.25†	–	–	–	–	–	–	–	–	1.38‡
15,	–	–	–	–	0.04†	0.17†	0.64†	–	–	–	–	*
16,	–	–	1.19†	–	–	0.06†	–	–	–	–	–	1.08§
17,	–	1.88‡	0.12†	–	–	–	0.02†	–	–	–	–	–
18,	0.03†	–	–	0.01†	–	–	–	–	*	0.02†	–	–
19,	–	–	0.14§	–	0.30†	0.25†	*	0.26†	*	–	–	–
20,	–	–	*	–	–	–	*	–	0.65†	–	–	–
21,	*	–	0.16†	0.01†	–	0.46†	1.08†	0.03†	–	–	–	*
22,	1.51†	0.89‡	–	–	–	–	0.19†	–	–	–	0.02†	1.68†
23,	–	–	–	–	–	–	–	–	–	0.13†	–	–
24,	–	–	–	–	–	–	–	–	–	0.02†	–	–
25,	–	–	–	0.13†	0.10†	–	–	0.03†	0.08†	–	*	0.86‡
26,	*	1.47†	–	0.46†	0.03†	0.30†	–	0.13†	*	–	*	0.01‡
27,	0.43§	–	0.02†	–	0.99†	–	0.02†	–	0.39†	*	0.84†	–
28,	–	1.55†	*	–	–	–	–	–	*	1.70†	–	–
29,	–	–	1.42†	–	–	0.09†	0.20†	–	*	–	–	0.15†
30,	0.01‡	–	0.04†	1.82†	–	0.11†	–	–	0.75†	–	0.27§	–
31,	0.01§	–	–	–	–	–	–	–	–	–	–	–
Totals,	2.71	6.65	6.45	4.62	1.79	2.42	2.97	4.07	4.34	4.20	1.36	6.61

Total for the year, 48.19 inches.

* Rainfall included in that of following day. † Rain. ‡ Snow.
§ Rain and snow.

TABLE NO. 4. — *Rainfall in Inches at Chestnut Hill Reservoir in 1902.*

DATE.	Amount.	Snow or Rain.	Duration.
Jan. 3,	0.02	Snow.	6 00 A.M. to 7.50 A.M.
Jan. 7,	0.47	Snow.	1.15 P.M. to 9.30 P.M.
Jan. 10,	0.02	Snow.	8.30 A.M. to 1.15 P.M.
Jan. 11, Jan. 12,	0.58	Snow.	6.00 P.M. to 11.00 A.M.
Jan. 21, Jan. 22,	0.70	Rain.	11.30 P.M. to 5.00 P.M.
Jan. 26, Jan. 27,	0.17	Snow and rain.	4.30 P.M. to 7.00 A.M.
Jan. 30,	0.02	Snow.	6 30 A.M. to 11.00 A.M.
Total,	1.98		
Feb. 1, Feb. 2,	1.11	Snow and rain.	6.30 A.M. to 10.30 P.M.
Feb. 4,	0.04	Rain.	5.30 P.M. to 7.00 P.M.
Feb. 12,	0.02	Snow.	2.00 A.M. to 5.30 A.M.
Feb. 12,	0.02	Snow.	7.00 P.M. to 11.30 P.M.
Feb. 17, Feb. 18,	2.16	Snow.	6.45 A.M. to 9.15 A.M.
Feb. 21, Feb. 22,	0.77	Snow.	2.00 P.M. to 3.30 P.M.
Feb. 25, Feb. 26,	1.51	Rain.	7.30 P.M. to 10.30 P.M.
Feb. 28,	2.13	Rain.	7.00 P.M. to 12.00 mid't.
Total,	7.76		
Mar. 2,	0.21	Rain.	9.00 A.M. to 3.30 P.M.
Mar. 5, Mar. 6,	1.71	Snow.	11.00 A.M. to 4.30 A.M.
Mar. 8, Mar. 9,	0.74	Rain.	12.00 midnight to 7.30 P.M.
Mar. 13, Mar. 14,	0.28	Rain.	4.00 P.M. to 2.30 A.M.
Mar. 16, Mar. 17,	0.81	Rain.	8.00 P.M. to 6.15 A.M.
Mar. 17,	0.11	Rain.	10.00 A.M. to 1.30 P.M.
Mar. 19,	0.11	Snow and rain.	6 30 A.M. to 9.30 P.M.
Mar. 20, Mar. 21,	0.13	Rain.	1.30 P.M. to 6.00 A.M.
Mar. 28, Mar. 29,	1.15	Rain.	5.30 P.M. to 2.00 P.M.
Mar. 31,	0.02	Rain.	2.00 A.M. to 4.00 A.M.
Total,	5.27		
Apr. 8, Apr. 9,	2.37	Rain.	2.00 P.M. to 2 00 P.M.
Apr. 26,	0.46	Rain.	1.15 A.M. to 8.30 P.M.
Apr. 30,	0.85	Rain.	2.00 A.M. to 2.00 P.M.
Apr. 30, May 1,	0.29	Rain.	11.15 A.M. to 2.30 A.M.
Total,	3.97		
May 4, May 5,	0.22	Rain.	4.00 P.M. to 4.30 A.M.
May 7,	0.07	Rain.	2.00 A.M. to 4 30 A.M.
May 13,	0.07	Rain.	4.30 A.M. to 7.30 A.M.
May 19,	0.44	Rain.	10.30 A.M. to 11 00 P.M.
May 25,	0.04	Rain.	7.00 P.M. to 10.15 P.M.
May 27,	0.27	Rain.	2 25 P.M. to 11.00 P.M.
Total,	1.11		
June 3,	0.19	Rain.	5.30 P.M. to 9.30 P.M.
June 7,	0.05	Rain.	1.30 P.M. to 7.30 P.M.
June 8,	0.26	Rain.	12.30 P.M. to 2.00 P.M.
June 10,	0.10	Rain.	4.00 P.M. to 6.30 P.M.
June 13,	0.36	Rain.	6.10 A.M. to 10.00 A.M.
June 15,	0.29	Rain.	5.30 A.M. to 9.00 P.M.
June 16, June 17,	0.05	Rain.	4.05 P.M. to 12.30 A.M.
June 19,	0.35	Rain.	12.50 P.M. to 6.00 P.M.
June 21, June 22,	0.53	Rain.	8.30 A.M. to 3.00 A.M.
June 26,	0.39	Rain.	4.00 A.M. to 10.15 A.M.
June 29,	0.09	Rain.	11.00 A.M. to 7.30 P.M.
June 30, July 1,	0.08	Rain.	5.30 P.M. to 6.45 A.M.
Total,	2.74		
July 1,	0.03	Rain.	9 30 A.M. to 1.30 P.M.
July 3,	0.38	Rain.	9.00 A.M. to 6.20 P.M.
July 6,	0.05	Showers.	During day.
July 8,	0.07	Rain.	8.00 A.M. to 10.30 A.M.
July 9, July 10,	0.40	Rain.	11.40 P.M. to 10.50 A.M.
July 15,	0.45	Rain.	5.00 P.M. to 9 30 P.M.
July 17,	0.53	Rain.	4.30 P.M. to 5.15 P.M.
July 19, July 20, July 21,	1.41	Rain.	6.15 A.M. to 7 00 A.M.
July 21,	0.06	Rain.	8 30 P.M. to 9.30 P.M.
July 22,	0.10	Rain.	6.10 P.M. to 8.00 P.M.
July 27,	0.04	Rain.	1.30 P.M. to 3.30 P.M.
Total,	3.52		
Aug. 4,	0.17	Rain.	4.40 P.M. to 5.25 P.M.
Aug. 6,	0.45	Rain.	7.30 A.M. to 2.30 P.M.
Aug. 7,	0.01	Rain.	3.30 A.M. to 3.45 A.M.
Aug. 8,	0.14	Rain.	6.45 A.M. to 8.30 A.M.
Aug. 11,	0.19	Rain.	4.30 A.M. to 7.00 A.M.
Aug. 11,	0.84	Rain.	10.30 A.M. to 2.30 P.M.
Aug. 11,	0.35	Rain.	8.00 P.M. to 10.00 P.M.
Aug. 18, Aug. 19,	0.44	Rain.	9.00 P.M. to 2.30 P.M.
Aug. 21,	0.03	Rain.	2.55 P.M. to 3.10 P.M.
Aug. 22, Aug. 23,	0.13	Rain.	5.00 P.M. to 5.00 A.M.
Aug. 25,	0.08	Rain.	2.13 P.M. to 2.40 P.M.
Aug. 25.	0.13	Rain.	5.45 P.M. to 8.15 P.M.
Total,	2.96		
Sept. 2,	0.08	Rain.	3.00 A.M. to 4.00 A.M.
Sept. 4,	0.60	Rain.	3.55 A.M. to 9.30 A.M.
Sept. 4,	0.08	Rain.	2.45 P.M. to 3.15 P.M.
Sept. 7,	0.21	Rain.	9 20 A.M. to 3 00 P.M.
Sept. 9, Sept. 10,	0.31	Rain.	4.00 P.M. to 12 20 A.M.
Sept. 13,	0.46	Rain.	12.15 P.M. to 5.30 P.M.
Sept. 19,	0.56	Rain.	12.30 A.M. to 2.45 P.M.
Sept 27, Sept. 28,	0.42	Rain.	4.00 A.M. to 4.30 A.M.
Sept. 28, Sept. 29,	0.39	Rain.	9.30 P.M. to 6.30 A.M.
Sept 30, Oct. 1,	0.20	Rain.	4.30 A.M. to 7.00 A.M.
Total,	3.31		

Table No. 4. — *Rainfall in Inches at Chestnut Hill Reservoir in 1902* — Concluded.

DATE.	Amount.	Snow or Rain.	Duration.
Oct. 1,	0.43	Rain.	7.00 A.M. to 10.00 P.M.
Oct. 5, Oct. 6,	0.78	Rain.	2.20 P.M. to 4.40 A.M.
Oct. 11, Oct. 12,	1.24	Rain.	5.30 P.M. to 2.30 P.M.
Oct. 22, Oct. 23,	0.28	Rain.	11.10 P.M. to 11.45 A.M.
Oct. 28,	1.33	Rain.	12.15 A.M. to 7.15 A.M.
Oct. 28,	0.58	Rain.	8.30 A.M. to 11.45 A.M.
Total,	4.64		
Nov. 11, Nov. 12,	0.12	Rain.	8.50 P.M. to 6.45 A.M.
Nov. 13,	0.04	Mist.	During day.
Nov. 22,	0.03	Rain.	8.00 P.M. to 9.00 P.M.
Nov. 26, Nov. 27,	1.03	Rain.	3.00 A.M. to 11.30 P.M.
Nov. 30, Dec. 1,	0.34	Rain.	7.50 P.M. to 3.30 A.M.
Total,	1.56		
Dec. 3,	0.52	Rain.	1.15 A.M. to 3.30 P.M.
Dec. 5,	0.39	Snow.	2.30 A.M. to 4.00 P.M.
Dec. 7,	0.19	Snow.	9.30 A.M. to 5.30 P.M.
Dec. 10,	0.03	Snow.	9.00 A.M. to 2.30 P.M.
Dec. 11, Dec. 12,	0.10	Snow.	6.45 P.M. to 7.10 A.M.
Dec. 13, Dec. 14,	0.60	Snow.	1.30 A.M. to 8.00 A.M.
Dec. 16, Dec. 17,	1.07	Snow and rain.	5.00 A.M. to 5 30 A.M.
Dec. 20, Dec. 21,	1.52	Rain.	11.10 A.M. to 5.15 A.M.
Dec. 25, Dec. 26,	0.82	Snow.	11.30 A.M. to 4.30 A.M.
Dec. 27,	0.05	Snow.	4.30 A.M. to 6.00 A.M.
Dec. 29, Dec. 30,	0.14	Rain.	4.30 P.M. to 2.30 A.M.
Total,	5.43		

Total for the year, 44.25 inches.

TABLE NO. 5. — *Rainfall in Inches on the Nashua Watershed* (South Branch), 1897 to 1902.*

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
1897, ...	3.46	2.86	4.01	2.32	5.06	5.11	8.65	3.47	1.93	0.94	7.62	6.41	51.84
1898, ...	6.65	3.30	2.27	4.43	3.38	3.11	3.01	10.61	3.15	7.21	6.81	3.99	57.92
1899, ...	2.93	5.12	6.75	1.94	1.33	5.51	3.82	3.20	4.11	2.72	1.94	2.03	41.40
1900, ...	4.56	8.69	6.19	2.76	4.34	3.59	3.20	3.18	3.46	2.90	6.44	3.15	52.46
1901, ...	1.75	1.13	5.82	9.64	7.02	1.51	5.66	4.58	3.10	3.70	2.43	9.36	55.76
1902, ...	2.72	4.91	5.27	4.36	2.24	2.51	3.87	3.95	4.26	6.36	0.93	7.20	48.58
Totals, . . .	22.07	26.01	30.31	25.45	23.37	21.34	28.21	28.99	20.01	23.83	26.17	32.14	307.90
Averages, . . .	3.68	4.33	5.05	4.24	3.90	3.56	4.70	4.83	3.34	3.97	4.36	5.36	51.32

* Means of observations at four places, as follows: January, 1897, to December, 1900, Princeton, Jefferson, Sterling and South Clinton; January, 1901, to December, 1902, Princeton, Jefferson, Sterling and Boylston.

TABLE No. 6. — *Rainfall in Inches on the Sudbury Watershed,* 1875 to 1902.*

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
1875,	2.42	3.15	3.74	3.23	3.56	6.24	3.57	5.53	3.43	4.85	4.83	0.94	45.49
1876,	1.83	4.21	7.43	4.20	2.76	2.04	9.13	1.72	4.62	2.24	5.76	3.62	49.56
1877,	3.22	0.74	8.36	3.43	3.70	2.43	2.95	3.68	0.32	8.52	5.80	0.87	44.02
1878,	5.63	5.97	4.69	5.79	0.96	3.88	2.97	6.94	1.29	6.42	7.02	6.37	57.93
1879,	2.48	3.56	5.14	4.72	1.58	3.79	3.93	6.51	1.88	0.81	2.68	4.34	41.42
1880,	3.57	3.98	3.31	3.11	1.84	2.14	6.27	4.01	1.60	3.74	1.78	2.83	38.18
1881,	5.56	4.65	5.73	2.00	3.51	5.39	2.35	1.36	2.62	2.95	4.09	3.96	44.17
1882,	5.95	4.55	2.65	1.82	5.07	1.66	1.77	1.67	8.74	2.07	1.15	2.30	39.40
1883,	2.81	3.87	1.78	1.84	4.19	2.40	2.68	0.73	1.52	5.60	1.81	3.55	32.78
1884,	5.09	6.54	4.72	4.41	3.47	3.44	3.67	4.65	0.85	2.48	2.65	5.17	47.14
1885,	4.71	3.87	1.07	3.60	3.48	2.87	1.43	7.18	1.43	5.09	6.09	2.72	43.54
1886,	6.36	6.28	3.61	2.22	3.00	1.47	3.27	4.10	2.90	3.24	4.64	4.97	46.06
1887,	5.20	4.78	4.90	4.27	1.16	2.65	3.76	5.28	1.32	2.83	2.67	3.88	42.70
1888,	4.15	3.68	6.02	2.43	4.82	2.54	1.41	6.22	8.59	4.99	7.22	5.40	57.47
1889,	5.37	1.65	2.37	3.41	2.95	2.80	8.94	4.18	4.60	4.25	6.29	3.14	49.95
1890,	2.53	3.51	7.73	2.64	5.21	2.03	2.46	3.87	6.00	10.51	1.20	5.31	53.00
1891,	7.02	5.23	6.48	3.91	2.01	3.77	3.39	4.73	2.38	3.83	3.09	3.68	49.52
1892,	5.85	3.14	4.06	0.83	5.58	2.76	4.23	4.44	2.84	1.17	5.80	1.13	41.83
1893,	2.92	8.20	3.67	3.60	6.61	2.38	2.57	5.41	1.74	4.07	2.20	4.86	48.23
1894,	4.09	3.91	1.43	3.42	4.24	1.15	3.26	2.03	2.63	5.34	3.43	4.81	39.74
1895,	4.06	1.39	2.98	5.25	2.02	2.77	5.04	4.15	2.30	10.68	6.63	3.35	50.62
1896,	2.39	7.18	5.24	1.57	2.57	3.22	2.51	2.40	7.72	3.76	3.02	2.12	43.70
1897,	4.00	2.91	3.66	2.82	4.37	4.46	5.44	3.51	2.94	0.47	6.40	5.21	46.19
1898,	6.83	4.49	2.40	4.66	3.22	2.48	4.09	8.17	2.62	6.71	6.93	3.28	55.88
1899,	4.18	4.91	7.01	1.90	1.45	2.51	3.22	1.43	3.95	2.69	2.18	1.78	37.21
1900,	4.96	9.14	6.35	2.58	4.32	2.99	2.42	2.26	3.36	3.83	5.70	2.74	50.65
1901,	1.82	1.52	6.57	8.60	7.23	1.38	5.71	4.57	3.30	2.82	2.90	9.69	56.11
1902,	2.52	6.18	5.34	4.13	1.86	2.89	2.94	3.40	4.54	4.44	1.45	6.38	46.07
Totals,	117.52	123.19	128.44	96.39	96.74	80.53	105.38	114.13	92.03	120.40	115.41	108.40	1,298.56
Averages,	4.20	4.40	4.59	3.44	3.45	2.88	3.76	4.08	3.29	4.30	4.12	3.87	46.38

* Means of observations at several places, as follows: January, 1875, to April, 1876, Lake Cochituate; April to June, 1876, Lake Cochituate, Westborough and Hopkinton; June to December, 1876, Lake Cochituate, Southborough, Marlborough, Westborough and Hopkinton; December, 1876, to January, 1883, Framingham, Southborough, Marlborough, Westborough and Hopkinton; January, 1883, to January, 1884, Framingham and Southborough; January, 1884, to January, 1890, Framingham and Westborough; January, 1890, to May, 1898, Framingham and Ashland Dam; June, 1898, to December, 1902, Framingham, Ashland Dam, Cordaville and Sudbury Dam.

TABLE NO. 7. — *Yield of the Nashua River (South Branch) in Gallons per Day per Square Mile* from 1897 to 1902.*

MONTHS.	1897.	1898.	1899.	1900.	1901.	1902.	Mean for 6 Years, 1897-1902.
January,	796,000	1,563,000	2,092,000	796,000	519,000	1,676,000	1,240,000
February,	931,000	1,635,000	1,090,000	4,054,000	356,000	1,401,000	1,578,000
March,	2,760,000	3,088,000	2,776,000	3,722,000	2,718,000	3,992,000	3,176,000
April,	1,632,000	2,027,000	3,376,000	1,580,000	4,986,000	2,159,000	2,627,000
May,	1,163,000	1,390,000	862,000	1,382,000	2,729,000	1,031,000	1,426,000
June,	1,181,000	828,000	561,000	578,000	985,000	410,000	757,000
July,	1,442,000	333,000	354,000	217,000	477,000	292,000	519,000
August,	896,000	1,325,000	236,000	197,000	512,000	297,000	577,000
September,	380,000	676,000	250,000	127,000	320,000	241,000	332,000
October,	243,000	1,509,000	245,000	282,000	647,000	950,000	646,000
November,	1,283,000	2,170,000	430,000	875,000	517,000	635,000	985,000
December,	2,275,000	2,061,000	359,000	1,570,000	3,234,000	1,848,000	1,891,000
Average for year,	1,253,000	1,551,000	1,051,000	1,264,000	1,507,000	1,248,000	1,312,000
Average for driest 6 months,	886,000	1,013,000	312,000	377,000	576,000	471,000	635,000

* The area of the watershed used in making up these records includes water surfaces amounting to 2.2 per cent. of the whole area.

TABLE NO. 8. — *Yield of the Sudbury Watershed in Gallons per Day per Square Mile* from 1875 to 1902.*

MONTHS.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.
January, ...	103,000	643,000	658,000	1,810,000	700,000	1,120,000	415,000	1,241,000	335,000	995,000	1,235,000	1,461,000	2,589,000	1,053,000	2,782,000
February, ...	1,496,000	1,368,000	949,000	2,465,000	1,711,000	1,787,000	1,546,000	2,403,000	1,033,000	2,842,000	1,354,000	4,801,000	2,829,000	1,950,000	1,196,000
March, ...	1,604,000	4,435,000	4,814,000	3,507,000	2,330,000	1,374,000	4,004,000	2,839,000	1,611,000	3,785,000	1,572,000	2,059,000	2,868,000	3,238,000	1,338,000
April, ...	3,049,000	3,292,000	2,394,000	1,626,000	3,116,000	1,169,000	1,546,000	867,000	1,350,000	2,853,000	1,815,000	1,947,000	2,620,000	2,645,000	1,410,000
May, ...	1,188,000	1,138,000	1,391,000	1,394,000	1,114,000	514,000	965,000	1,292,000	937,000	1,030,000	1,336,000	720,000	1,009,000	1,632,000	880,000
June, ...	870,000	222,000	597,000	506,000	413,000	175,000	1,338,000	529,000	300,000	416,000	426,000	203,000	413,000	421,000	653,000
July, ...	321,000	183,000	202,000	128,000	157,000	176,000	276,000	86,000	115,000	224,000	62,000	116,000	115,000	117,000	634,000
August, ...	396,000	405,000	121,000	476,000	395,000	119,000	148,000	55,000	79,000	257,000	240,000	94,000	214,000	379,000	1,432,000
September, . . .	207,000	184,000	60,000	161,000	141,000	80,000	197,000	307,000	91,000	44,000	121,000	117,000	111,000	1,155,000	823,000
October, ...	646,000	234,000	631,000	516,000	71,000	102,000	186,000	299,000	186,000	83,000	336,000	146,000	190,000	1,999,000	1,230,000
November, . . .	1,302,000	1,088,000	1,418,000	1,693,000	206,000	205,000	395,000	209,000	205,000	175,000	1,177,000	673,000	369,000	2,758,000	1,941,000
December, ...	584,000	453,000	1,290,000	3,177,000	463,000	175,000	775,000	315,000	194,000	925,000	1,174,000	1,020,000	643,000	3,043,000	2,241,000
Av. for year, . .	972,000	1,135,000	1,214,000	1,452,000	894,000	578,000	979,000	862,000	533,000	1,129,000	901,000	1,087,000	1,154,000	1,697,000	1,383,000
Av. for driest 6 mos.,	574,000	384,000	502,000	532,000	230,000	143,000	330,000	211,000	145,000	200,000	391,000	223,000	234,000	953,000	944,000

* The area of the Sudbury watershed used in making up these records included water surfaces amounting to 1.9 per cent. of the whole area from 1875 to 1878 inclusive, and subsequently increased by the construction of storage reservoirs to 3.0 per cent. in 1879, 3.4 per cent. in 1885, 3.9 per cent. in 1894 and 6.5 per cent. in 1898. The watershed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.

TABLE No. 8. — *Yield of the Sudbury Watershed in Gallons per Day per Square Mile* from 1875 to 1902* — Concluded.

MONTHS.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	Mean for 28 Years, 1875-1902.
January,	1,254,000	3,018,000	1,870,000	434,000	693,000	1,034,000	1,084,000	845,000	1,638,000	2,288,000	794,000	437,000	1,763,000	1,225,000
February,	1,529,000	3,486,000	943,000	1,542,000	991,000	541,000	2,676,000	1,067,000	3,022,000	1,381,000	3,800,000	300,000	1,674,000	1,881,000
March,	3,643,000	4,453,000	1,955,000	3,245,000	2,238,000	2,410,000	3,835,000	2,565,000	2,604,000	4,205,000	3,654,000	2,755,000	4,199,000	2,969,000
April,	1,875,000	2,397,000	871,000	2,125,000	1,640,000	2,515,000	1,494,000	1,515,000	1,829,000	2,521,000	1,350,000	4,204,000	1,885,000	2,068,000
May,	1,366,000	583,000	1,259,000	2,883,000	840,000	636,000	360,000	915,000	1,246,000	511,000	1,312,000	2,954,000	743,000	1,148,000
June,	568,000	413,000	428,000	440,000	419,000	174,000	399,000	962,000	530,000	66,000	316,000	753,000	303,000	473,000
July,	107,000	149,000	214,000	158,000	161,000	231,000	95,000	658,000	231,000	19,000	—18,000	306,000	66,000	189,000
August,	132,000	163,000	280,000	181,000	209,000	229,000	57,000	591,000	1,107,000	—35,000	—34,000	424,000	135,000	295,000
September,	457,000	203,000	229,000	108,000	150,000	89,000	388,000	182,000	369,000	94,000	65,000	305,000	178,000	236,000
October,	2,272,000	210,000	126,000	222,000	374,000	1,379,000	592,000	94,000	1,160,000	115,000	186,000	412,000	506,000	518,000
November,	1,215,000	305,000	697,000	319,000	836,000	2,777,000	659,000	909,000	1,986,000	304,000	663,000	474,000	444,000	907,000
December,	996,000	544,000	485,000	796,000	716,000	1,782,000	657,000	1,584,000	1,799,000	220,000	1,096,000	2,695,000	1,779,000	1,129,000
Av. for year,	1,285,000	1,315,000	781,000	1,037,000	770,000	1,152,000	1,019,000	991,000	1,450,000	973,000	1,082,000	1,342,000	1,140,000	1,083,000
Av. for driest 6 months,	747,000	239,000	327,000	237,000	356,000	460,000	314,000	564,000	777,000	93,000	194,000	445,000	271,000	435,000

* The area of the Sudbury watershed used in making up these records included water surfaces amounting to 1.9 per cent. of the whole area from 1875 to 1878 inclusive, and subsequently increased by the construction of storage reservoirs to 3.0 per cent. in 1879, 3.4 per cent. in 1885, 3.9 per cent. in 1894 and 6.5 per cent. in 1898. The watershed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.

TABLE NO. 9. — *Nashua River. — Statistics of Flow of Water, Storage and Rainfall in 1902.*

[Watershed = 119.00 square miles.]

MONTHS.	Quantity of Water discharged through Wachusett Aqueduct (Gallons per Day).*	Quantity of Water wasted into River (Gallons per Day).	STORAGE.† Gain (Gallons per Day).	STORAGE.† Loss (Gallons per Day).	Total Flow of River (Gallons per Day).	Rainfall (Inches).	Rainfall collected (Inches).	Percentage of Rainfall collected.
January,	117,171,000	88,081,000	-	5,765,000	199,487,000	2.72	2.990	110.1
February,	87,850,000	73,382,000	5,547,000	-	166,779,000	4.91	2.258	46.0
March,	30,877,000	446,958,000	-	2,803,000	475,032,000	5.27	7.120	135.0
April,	84,917,000	171,757,000	276,000	-	256,950,000	4.36	3.728	85.6
May,	92,032,000	37,471,000	-	6,819,000	122,684,000	2.24	1.839	81.9
June,	55,387,000	3,746,000	-	10,310,000	48,823,000	2.51	0.708	28.2
July,	35,584,000	3,458,000	-	4,307,000	34,735,000	3.87	0.521	13.4
August,	34,964,000	2,526,000	-	2,187,000	35,303,000	3.95	0.529	13.4
September,	28,383,000	2,653,000	-	2,393,000	28,643,000	4.26	0.416	9.8
October,	76,187,000	24,536,000	12,377,000	-	113,100,000	6.36	1.696	26.8
November,	74,217,000	5,946,000	-	4,653,000	75,510,000	0.93	1.095	117.1
December,	78,274,000	129,087,000	12,494,000	-	219,855,000	7.20	3.295	45.8
Totals,	-	-	-	-	-	48.58	26.195	-
Averages for year,	66,205,000	82,941,000	-	725,000	148,421,000	-	-	53.9

* Including small quantities wasted in cleaning aqueduct.

† In ponds and mill reservoirs.

TABLE No. 10. — *Sudbury River. — Statistics of Flow of Water, Storage and Rainfall in 1902.*

[Watershed from 1875 to 1878 inclusive = 77.761 square miles; in 1879 and 1880 = 78.238 square miles; and from 1881 to 1902 inclusive = 75.2 square miles.]

MONTHS.	Quantity of Water received through Wachusett Aqueduct (Gallons per Day).	Quantity of Water discharged through Sudbury Aqueduct (Gallons per Day).	Quantity of Water used by Framingham Water Company (Gallons per Day).	Quantity of Water diverted from Watershed by Sewers, etc (Gallons per Day).	Quantity of Water wasted into River below Lowest Dam (Gallons per Day).	Storage.		Total Flow of River (Gallons per Day).	Rainfall (Inches).	Rainfall collected (Inches).	Percentage of Rainfall collected.
						Gain (Gallons per Day).	Loss (Gallons per Day).				
January, . . .	117,171,000	105,584,000	448,000	1,097,000	131,481,000	11,148,000	-	132,587,000	2.52	3.145	125.0
February, . . .	87,850,000	104,754,000	404,000	1,043,000	111,139,000	-	3,611,000	125,879,000	6.18	2.697	43.6
March, . . .	30,877,000	100,106,000	377,000	2,442,000	222,868,000	20,861,000	-	315,777,000	5.34	7.491	140.3
April, ...	84,917,000	89,753,000	397,000	1,527,000	116,477,000	18,480,000	-	141,717,000	4.13	3.254	78.8
May, ...	92,032,000	102,806,000	387,000	713,000	37,010,000	6,971,000	-	55,855,000	1.80	1.325	71.3
June, ...	55,387,000	102,773,000	440,000	367,000	1,627,000	-	27,027,000	22,793,000	2.89	0.523	18.1
July, ...	35,584,000	85,268,000	413,000	177,000	1,432,000	-	46,780,000	4,926,000	2.94	0.117	4.0
August, . . .	34,055,000	80,361,000	442,000	132,000	1,439,000	-	38,190,000	10,129,000	3.40	0.240	7.1
September, . . .	28,383,000	86,550,000	493,000	40,000	1,500,000	-	46,783,000	13,417,000	4.54	0.308	6.8
October, . . .	76,187,000	90,381,000	403,000	510,000	1,500,000	21,419,000	-	38,026,000	4.44	0.902	20.3
November, . . .	74,217,000	93,380,000	403,000	557,000	13,157,000	137,000	-	33,417,000	1.45	0.767	52.7
December, . . .	78,274,000	106,580,000	429,000	1,416,000	67,155,000	36,497,000	-	133,803,000	6.38	3.173	49.8
Totals, . . .	-	-	-	-	-	-	-	-	46.07	23.942	-
Averages for year,	66,127,000	95,645,000	420,000	836,000	58,751,000	-	3,801,000	85,724,000	-	-	52.0

NOTE. — Slight discrepancies between the figures for the flow in the Wachusett Aqueduct in this table and those in Tables Nos. 9 and 13 are due to taking account of quantities wasted in cleaning the aqueduct, which were not discharged into Sudbury Reservoir.

TABLE NO. 11. — *Lake Cochituate. — Statistics of Flow of Water, Storage and Rainfall in 1902.*

[Watershed of lake = 18.87 square miles.*]

MONTHS.	Quantity of Water received from External Sources (Gallons per Day).	Quantity of Water discharged through Cochituate Aqueduct (Gallons per Day).	Quantity of Water diverted from Snake Brook† (Gallons per Day).	Quantity of Water diverted from Watershed by Sewers, etc (Gallons per Day).	Quantity of Water wasted at Outlet (Gallons per Day).	STORAGE. Gain (Gallons per Day).	STORAGE. Loss (Gallons per Day).	Quantity of Water collected in Lake (Gallons per Day).	Rainfall (Inches).	Rainfall collected (Inches).	Percentage of Rainfall collected.
January, . . .	-	3,635,000	2,942,000	1,100,000	12,652,000	4,929,000	-	25,258,000	2.11	2.388	113.2
February, . . .	-	1,807,000	54,000	807,000	8,050,000	12,868,000	-	23,586,000	6.67	2.014	30.2
March, . . .	-	12,910,000	-	1,148,000	58,158,000	1,229,000	-	73,445,000	5.04	6.942	137.8
April, ...	3,000‡	11,783,000	-	1,277,000	16,850,000	3,523,000	-	33,430,000	3.66	3.058	83.6
May, ...	-	5,458,000	-	706,000	7,484,000	-	2,006,000	11,642,000	1.24	1.101	88.8
June, ...	-	5,726,000	-	377,000	-	-	2,213,000	3,890,000	2.42	0.356	14.7
July, ...	-	22,590,000	-	300,000	-	-	18,032,000	4,858,000	3.53	0.459	13.0
August, . . .	-	23,558,000	-	229,000	-	-	16,419,000	7,368,000	3.39	0.697	20.5
September, . . .	1,713,000§	20,883,000	-	187,000	-	-	10,970,000	8,387,000	4.91	0.767	15.6
October, . . .	-	15,468,000	-	355,000	-	-	5,897,000	9,926,000	4.05	0.938	23.2
November, . . .	-	9,207,000	-	343,000	-	-	893,000	8,657,000	1.37	0.792	57.8
December, . . .	-	11,916,000	-	758,000	-	12,355,000	-	25,029,000	6.22	2.366	38.0
Totals, . . .	-	-	-	-	-	-	-	-	44.61	21.878	-
Averages for year,	141,000	12,165,000	77,000	809,000	8,652,000	-	1,906,000	19,656,000	-	-	49.0

* Not including the watershed of Dudley Pond.
‡ From Sudbury Aqueduct.
† On account of work in progress at Snake Brook Meadow.
§ From Dudley Pond.

TABLE NO. 12. — *Elevations of Water Surfaces of Reservoirs above Boston City Base at the Beginning of Each Month.*

DATES.	CHESTNUT HILL RESERVOIR. Ordinary High Water =134.00.		Lake Cochituate. High Water =144.36.	Dudley Pond. High Water =156.46.	Farm Pond High Water =159.25.	Spot Pond. High Water =163.00.	FRAMINGHAM RESERVOIR			Ashland Reservoir. Flash Boards 225.23.	Sudbury Reservoir. Flash Boards 259.97.	Hopkinton Reservoir. Flash Boards 305.00.	Whitehall Reservoir. Ordinary High Water =337.91.
	Bradlee Basin.	Lawrence Basin.					No. 1. Flash Boards 169.27.	No. 2. Flash Boards 177.12.	No. 3. Flash Boards 186.50.				
Jan. 1, 1902, .	133.89	133.93	141.65	154.29	159.43	163.78	168.39	176.53	183.86	224.90	257.35	304.89	338.30
Feb. 1, 1902, .	134.04	134.41	142.34	154.61	159.58	161.67	168.14	176.18	185.75	224.22	258.49	303.72	337.56
March 1, 1902, .	134.33	134.65	143.86	155.21	159.45	159.97	169.49	177.04	184.51	222.70	258.75	301.75	337.56
April 1, 1902, .	134.46	134.66	144.01	155.92	159.35	162.74	168.08	176.31	184.66	224.65	259.53	304.45	338.28
May 1, 1902, .	134.47	134.55	144.42	156.03	159.37	163.26	168.38	176.26	186.73	224.59	260.08	304.36	330.05
June 1, 1902, .	134.04	134.07	144.18	155.44	159.09	163.43	169.21	178.10	186.16	225.57	260.19	305.30	339.05
July 1, 1902, .	133.40	134.15	143.92	154.88	158.80	162.95	167.93	177.63	185.89	225.55	258.05	305.24	339.06
Aug. 1, 1902, .	132.02	133.58	141.51	154.43	158.60	163.10	168.35	175.66	184.16	225.51	256.11	301.39	339.02
Sept. 1, 1902, .	131.88	131.84	139.08	153.96	158.35	162.68	168.20	174.88	184.17	221.76	254.40	297.10	339.00
Oct. 1, 1902, .	132.18	132.29	137.35	152.23	158.31	162.99	168.21	175.98	184.33	216.77	251.92	293.23	338.64
Nov. 1, 1902, .	133.02	133.27	136.31	152.30	158.33	162.95	169.18	177.58	186.23	214.52	253.13	294.25	338.65
Dec. 1, 1902, .	133.03	133.10	136.15	152.18	158.23	162.82	167.77	177.09	184.71	215.79	253.43	295.63	338.53
Jan. 1, 1903, .	133.23	133.31	138.28	152.77	158.72	162.74	167.93	176.17	184.28	221.32	255.05	301.88	338.07

TABLE No. 13. — *Average Daily Quantity of Water flowing through Aqueducts in 1902, by Months.*

MONTHS.	Wachusett Aqueduct (Gallons).	Sudbury Aqueduct.			Cochituate Aqueduct (Gallons).
		From Framingham Reservoir No. 3 (Gallons).	From Framingham Reservoirs Nos. 1 and 2 (Gallons).	Total (Gallons).	
January, . .	117,171,000	105,584,000	–	105,584,000	3,635,000
February, . .	87,850,000	104,754,000	–	104,754,000	1,807,000
March, . . .	30,877,000	100,106,000	–	100,106,000	12,910,000
April, . . .	84,917,000	89,753,000	–	89,753,000	11,783,000
May, . . .	92,032,000	97,045,000	5,761,000	102,806,000	5,458,000
June, . . .	55,387,000	91,430,000	11,343,000	102,773,000	5,726,000
July, . . .	35,584,000	63,874,000	21,394,000	85,268,000	22,590,000
August, . .	34,964,000	55,248,000	25,113,000	80,361,000	23,558,000
September, . .	28,383,000	61,430,000	25,120,000	86,550,000	20,883,000
October, . .	76,187,000	63,545,000	28,836,000	90,381,000	15,468,000
November, . .	74,217,000	85,883,000	7,497,000	93,380,000	9,207,000
December, . .	78,274,000	106,580,000	–	106,580,000	11,916,000
Averages, .	66,205,000	85,314,000	10,331,000	95,645,000	12,165,000

TABLE No. 14. — *Statement of Operations of Engine No. 1 at Chestnut Hill High-service Pumping Station for the Year 1902.*

MONTHS.	Total Pumping Time. Hrs.	Total Pumping Time. Min.	Amount pumped, 4.23 Per Cent. allowed for Slip (Million Gallons).	Amount of Coal consumed (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	Average Lift (Feet).	Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting, 4.23 Per Cent. allowed for Slip.	Duty in Foot-pounds per 100 Pounds of Coal, on Basis of Plunger Displacement, no Deduction for Heating or Lighting.
January,	5	30	2.15	–	–	–	–	105.48	–	–
February,	–		–	–	–	–	–	–	–	–
March,	–		–	–	–	–	–	–	–	–
April,	168	40	71.86	103,446	8,857	8.6	694.66	120.09	69,490,000	72,550,000
May,	14	25	6.53	9,866	1,012	10.8	697.20	119.03	69,130,000	72,180,000
June,	105	45	44.30	63,032	6,505	10.3	702.82	118.67	69,480,000	72,540,000
July,	68	30	28.95	39,070	4,446	11.4	740.98	120.00	74,070,000	77,340,000
August,	9	25	4.19	5,879	704	12.0	712.71	120.80	71,720,000	74,880,000
September,	34	20	15.86	21,848	2,334	10.7	725.92	121.02	73,180,000	76,410,000
October,	88	00	38.59	53,232	5,576	10.5	724.94	120.28	72,630,000	75,830,000
November,	–		–	–	–	–	–	–	–	–
December,	135	40	61.47	84,544	9,209	10.9	727.08	120.44	72,950,000	76,170,000
Totals and averages,	634	15	273.90	380,417	38,643	10.2	720.00	119.99	71,960,000	75,130,000

TABLE NO. 15. — *Statement of Operations of Engine No. 3 at Chestnut Hill High-service Pumping Station for the Year 1902.*

MONTHS.	Total Pumping Time. Hrs.	Total Pumping Time. Min.	Amount pumped, 3.03 Per Cent. allowed for Slip (Million Gallons).	Amount of Coal consumed (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	Average Lift (Feet).	Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting, 3.03 Per Cent. allowed for Slip.	Duty in Foot-pounds per 100 Pounds of Coal, on Basis of Plunger Displacement, no Deduction for Heating or Lighting.
January,	-		-	-	-	-	-	-	-	-
February,	-		-	-	-	-	-	-	-	-
March,	-		-	-	-	-	-	-	-	-
April,	261	55	258.31	235,716	23,492	10.0	1,095.85	125.90	114,930,000	118,520,000
May,	4	10	4.18	4,467	491	11.0	935.75	126.67	98,740,000	101,820,000
June,	94	30	95.86	75,105	8,087	10.8	1,276.35	118.86	126,370,000	130,310,000
July,	22	00	20.93	17,451	1,867	10.7	1,199.30	123.67	123,550,000	127,400,000
August,	-		-	-	-	-	-	-	-	-
September,	-		-	-	-	-	-	-	-	-
October,	123	30	124.11	110,395	11,999	10.9	1,124.24	122.76	114,960,000	118,550,000
November,	-		-	-	-	-	-	-	-	-
December,	-		-	-	-	-	-	-	-	-
Totals and averages,	506	05	503.39	443,134	45,936	10.4	1,135.98	123.70	117,050,000	120,700,000

TABLE NO. 16.—*Statement of Operations of Engine No. 4 at Chestnut Hill High-service Pumping Station for the Year 1902.*

MONTHS.	Total Pumping Time.	Amount pumped, 1.47 Per Cent. allowed for Slip (Million Gallons).	Amount of Coal consumed (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	Average Lift (Feet).	Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting, 1.47 Per Cent. allowed for Slip.	Duty in Foot-pounds per 100 Pounds of Coal, on Basis of Plunger Displacement, no Deduction for Heating or Lighting.	SUMMARY OF ENGINES NOS. 1, 2, 3 AND 4 — Total Amount pumped, Allowance made for Slip (Million Gallons).	SUMMARY OF ENGINES NOS. 1, 2, 3 AND 4 — Daily Average Amount pumped (Million Gallons).
	Hrs. Min.										
January,	740 20	896.08	705,365	69,133	9.8	1,270.38	127.88	135,330,000	137,360,000	898.23	28.975
February,	672 00	814.83	638,359	56,821	8.9	1,276.44	128.07	136,170,000	138,220,000	814.83	29.101
March,	742 20	882.36	688,986	65,096	9.4	1,280.66	127.30	135,800,000	137,840,000	882.36	28.463
April,	455 25	541.79	417,040	44,420	10.7	1,299.13	127.44	137,910,000	139,980,000	871.96	29.065
May,	738 45	908.93	726,289	81,344	11.2	1,251.47	126.71	132,090,000	134,070,000	919.64	29.666
June,	622 10	781.25	622,950	70,408	11.3	1,254.11	128.48	134,220,000	136,230,000	921.41	30.714
July,	722 05	875.27	696,100	81,812	11.8	1,257.39	128.90	135,010,000	137,040,000	925.15	29.844
August,	742 20	925.73	728,141	85,859	11.8	1,271.36	130.73	138,450,000	140,530,000	929.92	29.997
September,	720 00	902.94	725,754	81,693	11.3	1,244.14	128.98	133,670,000	135,680,000	918.80	30.627
October,	619 15	767.76	619,666	67,601	10.9	1,238.99	130.29	134,470,000	136,490,000	930.46	30.015
November,	720 00	883.89	745,475	80,475	10.8	1,185.67	128.08	126,500,000	128,400,000	883.89	29.463
December,	743 30	937.78	764,041	88,979	11.6	1,227.39	128.07	130,940,000	132,900,000	999.25	32.234
Totals and averages,	8,238 10	10,118.61	8,078,166	873,641	10.8	1,252.59	128.43	134,000,000	136,010,000	10,895.90	29.852

TABLE No. 17. — *Statement of Operations of Engines Nos. 5, 6 and 7 at Chestnut Hill Low-service Pumping Station for the Year 1902.*

MONTHS.	Engine No. 5.		Engine No 6.		Engine No. 7.		Total Amount pumped (Million Gallons).	Daily Average Amount pumped (Million Gallons).	Total Amount of Coal consumed (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	Average Lift (Feet).			Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting, 1.53 Per Cent. allowed for Slip.	Duty in Foot-pounds per 100 Pounds of Coal, on Basis of Plunger Displacement, no Deduction for Heating or Lighting.
	Total Pumping Time.	Amount Pumped, 1.53 Per Cent. allowed for Slip (Million Gallons).	Total Pumping Time.	Amount pumped, 1.53 Per Cent. allowed for Slip (Million Gallons).	Total Pumping Time.	Amount pumped, 1.53 Per Cent. allowed for Slip (Million Gallons).						Engine No. 5.	Engine No. 6.	Engine No. 7.		
	Hrs. Min.		Hrs. Min.		Hrs Min.											
January, ...	663 20	809.02	682 55	823.73	659 20	793.93	2,426.68	78.280	729,606	9.1	3,326.01	40.94	40.92	40.45	112,960,000	114,710,000
February, ...	609 05	733.60	587 40	703.92	590 20	708.02	2,145.54	76.626	584,967	9.4	3,667.80	37.21	37.20	37.17	113,640,000	115,400,000
March, ...	744 00	797.10	740 55	793.09	735 45	1,005.69	2,595.88	83.738	832,371	9.5	3,118.66	61.16	61.21	25.40	122,930,000	124,840,000
April, ...	454 25	578.30	602 25	794.14	571 00	778.22	2,150.66	71.689	619,882	9.5	3,469.47	52.51	50.94	25.77	122,120,000	124,010,000
May, ...	633 50	778.12	672 55	837.35	535 05	708.78	2,324.25	74.976	691,795	9.2	3,359.74	54.82	54.30	24.14	126,710,000	128,670,000
June, ...	584 05	726.52	491 55	596.24	703 25	933.03	2,255.79	75.193	635,830	10.1	3,547.79	55.73	56.59	22.60	124,870,000	126,800,000
July, ...	598 35	735.52	550 10	664.16	720 00	966.98	2,366.66	76.344	707,062	10.3	3,347.17	58.79	59.19	24.16	124,780,000	126,710,000
August, ...	521 40	636.65	547 25	663.67	721 00	956.55	2,256.87	72.802	652,473	10.1	3,458.95	55.81	55.49	24.50	122,300,000	124,200,000
September, ...	586 40	733.37	461 00	562.69	709 20	960.33	2,256.39	75.213	684,633	10.2	3,295.77	57.61	59.08	24.56	120,580,000	122,450,000
October, ...	374 15	450.37	602 45	783.84	740 15	1,019.02	2,253.23	72.685	626,756	10.0	3,595.07	53.44	51.30	23.41	117,140,000	118,960,000
November, ...	477 30	612.46	547 00	704.34	625 55	858.41	2,175.21	72.507	656,814	10.1	3,311.76	50.30	50.21	23.72	109,740,000	111,440,000
December, ...	684 50	857.25	666 10	828.73	744 00	1,048.81	2,734.79	88.219	853,275	9.9	3,205.05	55.44	55.51	23.90	115,780,000	117,570,000
Totals and averages,	6,932 15	8,448.28	7,153 15	8,755.90	8,055 25	10,737.77	27,941.95	76.553	8,275,464	9.8	3,376.48	52.81	52.42	26.25	119,490,000	121,340,000

TABLE No. 18. — *Statement of Operations of Engine No. 9 at Spot Pond Pumping Station for the Year 1902.*

MONTHS.	Total Pumping Time. Hrs.	Total Pumping Time. Min.	Amount pumped, 1.63 Per Cent. allowed for Slip (Million Gallons).	Amount of Coal consumed (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	Average Lift (Feet).	Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting, 1.63 Per Cent. allowed for Slip.	Duty in Foot-pounds per 100 Pounds of Coal on Basis of Plunger Displacement, no Deduction for Heating or Lighting.
January,	324	50	249.37	200,317	17,762	8.9	1,244.88	119.14	123,550,000	125,600,000
February,	285	25	236.26	187,751	17,104	9.1	1,258.37	122.87	128,800,000	130,940,000
March,	311	15	255.50	188,738	18,436	9.8	1,353.73	120.47	135,850,000	138,110,000
April,	289	50	239.63	171,979	16,012	9.3	1,393.37	119.49	138,690,000	140,990,000
May,	325	45	269.23	188,445	18,942	10.1	1,428.69	119.54	142,260,000	144,620,000
June,	338	25	282.06	198,828	18,284	9.2	1,418.61	121.57	143,660,000	146,040,000
July,	321	45	268.75	206,398	19,868	9.6	1,302.10	128.86	139,770,000	142,090,000
August,	299	05	250.24	195,940	20,360	10.4	1,277.13	127.05	135,160,000	137,400,000
September,	270	10	227.81	181,197	22,303	12.3	1,257.25	126.37	132,350,000	134,550,000
October,	246	30	209.10	169,009	22,748	13.5	1,237.21	126.66	130,540,000	132,710,000
November,	233	15	193.59	164,623	20,029	12.2	1,175.96	127.06	124,460,000	126,530,000
December,	287	20	237.47	214,231	26,165	12.2	1,108.48	127.34	117,580,000	119,530,000
Totals and averages,	3,533	35	2,919.01	2,267,456	238,013	10.5	1,287.35	123.73	132,680,000	134,880,000

TABLE NO. 19. — *Average Daily Consumption of Water during the Year 1902, in the Cities and Towns supplied wholly or in Part by the Metropolitan Water Works, including Boston, Somerville, Chelsea, Malden, Everett, Quincy, Medford, Melrose, Revere, Watertown, Arlington, Milton, Stoneham, Winthrop, Swampscott, Belmont, Nahant and a Small Portion of Saugus. (For Consumption of Water in Whole Metropolitan Water District see Table No. 23.)*

MONTHS.	Supplied by Metropolitan Works (Million Gallons).	Supplied from Local Sources (Million Gallons).*	Total (Million Gallons).	Estimated Population.	Consumption per Inhabitant (Gallons).
January,	115.088	.603	115.691	864,000	134
February,	114.177	.276	114.453	865,900	132
March,	105.532	.009	105.541	867,700	122
April,	100.280	.018	100.298	869,500	115
May,	103.398	.026	103.424	871,400	119
June,	106.468	.028	106.496	873,300	122
July,	105.041	.021	105.062	875,100	120
August,	103.815	.014	103.829	877,000	118
September,	104.560	–	104.560	878,800	119
October,	103.564	–	103.564	880,700	118
November,	102.198	–	102.198	882,600	116
December,	122.288	–	122.288	884,400	138
For the year,	107.186	.082	107.268	874,200	123

* The entire town of Milton was supplied by the Hyde Park Water Company until February 28 and a portion of the town until August 22. A portion of the supply of the city of Medford was taken from Wright's Pond from January 4 to 22.

TABLE NO. 20. — *Average Daily Consumption of Water from the Low Service (1902).*

MONTHS.	Southern Low Service of Boston excluding East Boston and Charlestown (Million Gallons).	SOMERVILLE, CHELSEA, EVERETT, MALDEN, MEDFORD, CHARLESTOWN, EAST BOSTON, MELROSE AND ARLINGTON.			Total Low-service Consumption (Million Gallons).
		Supplied from Metropolitan Sources (Million Gallons).	Gravity Supply to Medford from Wright's Pond (Million Gallons).	Total Northern Low-service Consumption (Million Gallons).	
January,	47.411	30.248	.317	30.565	77.976
February,	46.756	29.697	–	29.697	76.453
March,	42.002	26.600	–	26.600	68.602
April,	40.013	22.994	–	22.994	63.007
May,	40.834	23.883	–	23.883	64.717
June,	40.764	25.357	–	25.357	66.121
July,	40.860	25.167	–	25.167	66.027
August,	40.573	24.820	–	24.820	65.393
September,	39.798	26.199	–	26.199	65.997
October,	41.087	25.194	–	25.194	66.281
November,	40.387	25.722	–	25.722	66.109
December,	49.276	32.971	–	32.971	82.247
For the year,	42.469	26.562	.027	26.589	69.058

TABLE No. 21. — *Average Daily Consumption of Water, in Million Gallons, from the Southern High-service and the Southern Extra High-service Works, supplying Quincy, Watertown, Belmont, Milton and the Higher Portions of Boston (1902).*

MONTHS.	SOUTHERN HIGH SERVICE.			SOUTHERN EXTRA HIGH SERVICE.		
	Pumped at Chestnut Hill High-service Station.*	Pumped by Hyde Park Water Company for Milton.	Totals.	Pumped at Chestnut Hill High service Station and again at West Roxbury.	Pumped by Hyde Park Water Company for Milton.	Totals.
January,	28.678	.270†	28.948	.275	.016†	.291
February,	28.854	.261†	29.115	.265	.015†	.280
March,	28.214	–	28.214	.266	.009	.275
April,	28.735	–	28.735	.278	.018	.296
May,	29.290	–	29.290	.353	.026	.379
June,	30.270	–	30.270	.399	.028	.427
July,	29.592	–	29.592	.363	.021	.384
August,	29.578	–	29.578	.374	.014	.388
September,	30.232	–	30.232	.409	–	.409
October,	29.694	–	29.694	.406	–	.406
November,	28.965	–	28.965	.439	–	.439
December,	31.845	–	31.845	.388	–	.388
For the year,	29.500	.043	29.543	.352	.012	.364

* All except a small portion of Milton supplied from the Metropolitan Water Works after February 28, and the entire town since August 22.

† The proportion used by the high-service and extra high-service districts in Milton during January and February has been estimated.

TABLE No. 22. — *Average Daily Consumption of Water, in Million Gallons, from the Northern High Service, supplying Revere, Winthrop, Swampscott, Nahant and Stoneham, and the Higher Portions of Breed's Island, Chelsea, Everett, Malden, Medford, Melrose and Somerville and from the Northern Extra High Service supplying the Higher Portion of Arlington (1902).*

MONTHS.	Northern High Service. Pumped at Spot Pond Station.	Northern Extra High Service Pumped at Arlington Station.
January,	8.215	.261
February,	8.350	.255
March,	8.201	.249
April,	7.995	.265
May,	8.716	.322
June,	9.273	.405
July,	8.689	.370
August,	8.146	.324
September,	7.569	.353
October,	6.845	.338
November,	6.442	.243
December,	7.552	.256
For the year,	7.999	.304*

* In addition to the above, 4,320,000 gallons of water, equivalent to 11,000 gallons per day, were supplied to the town of Lexington from this service.

TABLE No. 23. — *Consumption of Water in the Metropolitan Water District as constituted December 31, 1902, the Towns of Milton and Swampscott and a Small Portion of Saugus, 1893–1902.*

[Gallons per Day.]

MONTHS.	1893.	1894.	1895.	1896.	1897.
January,	75,113,000	67,409,000	68,829,000	82,817,000	85,269,000
February,	71,757,000	68,801,000	80,232,000	86,883,000	83,824,000
March,	67,509,000	62,581,000	69,414,000	85,982,000	82,590,000
April,	62,142,000	57,549,000	62,742,000	77,363,000	79,747,000
May,	60,864,000	60,483,000	65,000,000	73,209,000	76,579,000
June,	63,174,000	68,129,000	69,705,000	77,405,000	77,718,000
July,	69,104,000	73,399,000	69,422,000	79,752,000	85,267,000
August,	66,758,000	67,770,000	72,007,000	78,311,000	83,872,000
September,	64,454,000	66,937,000	73,490,000	73,960,000	84,063,000
October,	63,577,000	62,541,000	66,834,000	71,569,000	79,358,000
November,	61,037,000	62,064,000	64,714,000	71,766,000	72,595,000
December,	66,571,000	64,979,000	70,314,000	79,320,000	76,465,000
Averages for the year,	65,994,000	65,208,000	69,322,000	78,181,000	80,609,000
Population,	719,775	739,917	760,059	782,821	805,582
Consumption per inhabitant,	91.7	88.1	91.2	99.9	100.1

MONTHS.	1898.	1899.	1900.	1901.	1902.
January,	83,751,000	96,313,000	99,926,000	111,146,000	118,273,000
February,	87,332,000	103,311,000	98,802,000	117,318,000	117,089,000
March,	85,306,000	90,039,000	97,591,000	105,348,000	108,300,000
April,	76,407,000	86,325,000	89,297,000	93,117,000	102,953,000
May,	76,483,000	89,254,000	87,586,000	95,374,000	106,499,000
June,	83,263,000	97,457,000	98,348,000	103,186,000	109,768,000
July,	87,995,000	96,584,000	107,545,000	102,557,000	108,082,000
August,	87,300,000	91,814,000	102,459,000	102,557,000	106,787,000
September,	88,063,000	91,245,000	103,379,000	101,869,000	107,519,000
October,	81,576,000	89,387,000	98,165,000	103,195,000	106,367,000
November,	78,011,000	86,552,000	93,482,000	101,158,000	105,008,000
December,	86,194,000	85,678,000	97,683,000	113,106,000	125,272,000
Averages for the year,	83,464,000	91,921,000	97,866,000	104,449,000	110,145,000
Population,	828,344	851,105	873,867	897,700	921,600
Consumption per inhabitant,	100.8	108.0	112.0	116.4	119.5

This table includes the water consumed in the cities and towns enumerated in Table No. 19, together with the water consumed in Newton and Hyde Park, which are included in the Metropolitan Water District bnt have not been supplied from the Metropolitan Works.

Note relating to Chemical Examinations of Water, Tables Nos. 24–30.

The chemical examinations contained in the tables were made by the State Board of Health. Colors have been determined by the Nessler standard, but the corresponding values by the platinum standard are also given, for the purpose of comparison with colors determined in the laboratory of the Metropolitan Water and Sewerage Board, as given in subsequent tables. The odor recorded is taken in such a way that it is a much stronger odor than would be noticed in samples drawn directly from a tap or collected directly from a reservoir. In nearly all cases the samples are collected and examined monthly; in the case of the Sudbury Reservoir, however, they are made weekly.

Table No. 24. — *Chemical Examinations of Water from the Nashua River above the Temporary Dam at Clinton.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.		Appearance. Color.		Odor.		Residue on Evaporation.		Ammonia.	Ammonia. Albuminoid.			Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Nessler Standard	Transformed to Platinum Standard.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1902.																	
38506	Jan. 1	Decided.	Cons.	.43	.41	Faintly unpleasant.	Distinctly unpleasant.	3.00	1.05	.0026	.0164	.0154	.0010	.14	.0080	.0000	.53	1.0
38857	Feb. 3	V. slight	Slight.	.28	.32	Faintly vegetable.	Distinctly vegetable.	3.00	1.00	.0010	.0128	.0110	.0018	.18	.0110	.0000	.43	0.6
39210	March 3	Decided.	Cons.	.40	.39	Faintly vegetable.	Distinctly vegetable.	3.00	1.65	.0064	.0306	.0188	.0118	.15	.0060	.0002	.58	0.3
39477	March 31	Slight.	Cons.	.35	.36	Distinctly vegetable.	Decidedly vegetable.	3.00	1.25	.0010	.0192	.0176	.0016	.16	.0070	.0000	.51	0.5
39907	May 5	V. slight.	Slight.	.45	.42	Faintly vegetable.	Faintly vegetable.	3.25	1.50	.0006	.0192	.0176	.0016	.15	.0050	.0001	.56	0.8
40290	June 2	Slight.	Slight.	.44	.42	Faintly vegetable.	Distinctly vegetable.	4.00	1.90	.0012	.0188	.0168	.0020	.21	.0020	.0000	.55	0.8
40846	June 30	V. slight.	Slight.	.30	.33	None.	Faintly vegetable.	3.50	1.30	.0028	.0202	.0160	.0042	.26	.0050	.0001	.35	0.6
41462	Aug. 4	Slight.	Slight.	.31	.34	Faintly unpleasant	Faintly unpleasant.	4.00	1.65	.0048	.0248	.0212	.0036	.32	.0010	.0001	.45	1.3
42027	Sept. 2	Decided.	Cons.	.21	.27	Faintly vegetable.	Distinctly vegetable.	4.20	1.70	.0024	.0204	.0178	.0026	.25	.0000	.0001	.45	1.1
42523	Sept. 29	Slight.	Cons.	.28	.32	Faintly vegetable.	Distinctly vegetable.	4.15	1.50	.0040	.0126	.0108	.0018	.29	.0010	.0002	.33	1.6
43036	Nov. 3	V. slight.	V. slight.	.73	.59	Faintly vegetable.	Distinctly vegetable.	4.60	1.85	.0020	.0174	.0164	.0010	.25	.0050	.0002	.87	1.1
43352	Dec. 1	V. slight.	Slight	.30	.37	Faintly vegetable.	Distinctly vegetable.	3.75	1.50	.0018	.0160	.0144	.0016	.27	.0090	.0000	.43	1.1
Av.	....	....	....	.38	.38	....	....	3.62	1.49	.0025	.0190	.0161	.0029	.22	.0050	.0001	.50	0.9

TABLE No. 25. — *Chemical Examinations of Water from Framingham Reservoir No. 3.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.		Appearance. Color.		Odor.		Residue on Evaporation.		Ammonia.	Ammonia. Albuminoid.			Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Nessler Standard.	Transformed to Platinum Standard.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1902.																	
38493	Jan. 1	V. slight.	Slight.	.33	.35	Faintly vegetable.	Distinctly vegetable.	4.10	1.90	.0036	.0166	.0144	.0022	.29	.0140	.0000	.54	1.7
38830	Feb. 3	V. slight.	Slight.	.35	.36	Faintly vegetable.	Distinctly vegetable.	4.30	1.60	.0048	.0146	.0134	.0012	.23	.0220	.0001	.49	1.3
39202	March 3	Decided.	Cons.	.33	.35	Faintly vegetable.	Distinctly vegetable.	3.45	1.45	.0036	.0146	.0106	.0040	.21	.0030	.0002	.43	0.8
39480	March 31	Slight.	Slight.	.25	.29	Faintly vegetable.	Distinctly vegetable.	3.35	1.25	.0018	.0118	.0086	.0032	.23	.0180	.0000	.39	0.8
39896	May 5	V. slight.	Slight.	.25	.29	None.	Faintly vegetable.	3.70	1.40	.0008	.0176	.0140	.0036	.22	.0110	.0001	.38	1.1
40286	June 2	V. slight.	Cons.	.25	.29	Faintly vegetable.	Distinctly vegetable.	4.00	1.50	.0010	.0146	.0112	.0034	.23	.0090	.0002	.36	1.0
40830	June 30	V. slight.	Slight.	.21	.27	Faintly vegetable.	Distinctly vegetable.	3.35	1.30	.0026	.0166	.0130	.0036	.25	.0050	.0001	.36	1.0
41456	Aug. 4	V. slight.	Slight.	.10	.18	None.	None.	2.95	1.00	.0022	.0140	.0124	.0016	.25	.0020	.0002	.32	1.6
41983	Sept. 2	V. slight.	Slight.	.11	.19	Distinctly unpleasant. Pigpen.	Decidedly unpleasant. Pigpen.	5.25	1.40	.0054	.0284	.0244	.0040	.66	.0000	.0000	.30	1.4
42493	Sept. 29	V. slight.	Slight.	.10	.18	Faintly vegetable.	Distinctly vegetable and grassy.	3.45	1.10	.0004	.0152	.0120	.0032	.28	.0010	.0000	.33	1.3
42999	Nov. 3	Slight.	Slight.	.16	.23	None.	Faintly vegetable.	3.70	1.60	.0012	.0142	.0126	.0016	.29	.0000	.0000	.36	1.3
43371	Dec. 2	V. slight.	Slight.	.35	.36	Faintly vegetable.	Distinctly vegetable.	4.00	1.60	.0044	.0128	.0120	.0008	.28	.0060	.0001	.55	1.8
Av...	....	....	....	.23	.28	....	....	3.80	1.42	.0026	.0159	.0132	.0027	.28	.0076	.0001	.40	1.3

TABLE No. 26. — *Chemical Examinations of Water from Lake Cochituate.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.				Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.		Cold.	Hot.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
				Nessler Standard.	Transformed to Platinum Standard.						Total.	Dissolved.	Suspended.					
	1902.																	
38505	Jan. 1	V. slight.	Slight.	.32	.34	Faintly unpleasant.	Decidedly unpleasant.	5.50	2.10	.0060	.0206	.0178	.0028	.44	.0150	.0004	.48	2.2
38829	Feb. 3	Slight.	Slight.	.34	.35	Faintly unpleasant.	Decidedly unpleasant and cucumber.	4.90	1.80	.0040	.0198	.0176	.0022	.33	.0140	.0001	.57	2.1
39203	March 3	Slight.	Slight.	.35	.36	Faintly unpleasant.	Distinctly unpleasant.	5.50	2.00	.0014	.0200	.0160	.0040	.40	.0200	.0002	.56	2.0
39481	March 31	V. slight	Slight.	.32	.34	Distinctly vegetable.	Faintly unpleasant and fishy	4.65	1.90	.0020	.0172	.0144	.0028	.40	.0180	.0004	.53	1.8
39903	May 5	V. slight.	Cons.	.33	.35	None.	V. faintly vegetable.	4.30	1.90	.0028	.0222	.0176	.0046	.36	.0140	.0004	.50	1.8
40287	June 2	V. slight.	Slight.	.27	.31	Faintly vegetable.	Distinctly vegetable and grassy.	4.90	1.90	.0012	.0186	.0154	.0032	.41	.0070	.0003	.38	1.6
40827	June 30	V. slight.	V. slight.	.22	.27	Faintly vegetable.	Distinctly vegetable.	4.30	1.85	.0022	.0194	.01[illegible]	.0012	.43	.0110	.0002	.40	1.6
41455	Aug. 4	V. slight.	Slight.	.20	.26	None.	V. faintly vegetable.	4.50	1.70	.0018	.0166	.0154	.0012	.43	.0050	.0003	.43	2.0
41992	Sept. 1	V. slight.	Slight.	.12	.20	Faintly vegetable.	Distinctly vegetable and grassy.	4.60	1.90	.0036	.0242	.0196	.0046	.47	.0020	.0002	.41	1.8
42492	Sept. 29	V. slight.	Slight.	.11	.19	Faintly vegetable.	Distinctly vegetable.	4.40	2.00	.0012	.0204	.0150	.0054	.48	.0030	.0001	.43	2.0
43000	Nov. 3	V. slight.	Cons., Cyclops.	.15	.22	Distinctly vegetable.	Decidedly vegetable.	5.00	2.10	.0018	.0130	.0112	.0018	.46	.0050	.0002	.35	2.1
43390	Dec. 2	V. slight.	Cons.	.32	.34	Distinctly vegetable.	Distinctly vegetable and grassy.	4.70	1.70	.0058	.0182	.0144	.0038	.44	.0060	.0002	.44	2.0
Av.	....	....	....	.25	.29	....	....	4.77	1.90	.0028	.0192	.0161	.0031	.42	.0100	.0002	.46	1.9

TABLE NO. 27. — *Chemical Examinations of Water from Spot Pond, Stoneham.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.				Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.		Cold.	Hot.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
				Nessler Standard.	Transformed to Platinum Standard.						Total.	Dissolved.	Suspended.					
	1902.																	
38490	Jan. 1	V. slight.	V. slight.	.08	.15	None.	Faintly vegetable.	4.55	1.60	.0027	.0167	.0150	.0017	.32	.0010	.0000	.31	2.0
38832	Feb. 3	None.	V. slight.	.08	.15	None.	Faintly vegetable.	4.65	1.40	.0048	.0180	.0160	.0020	.34	.0020	.0001	.30	2.2
39191	March 3	None.	None.	.08	.15	Faintly vegetable.	Distinctly vegetable.	4.25	1.45	.0029	.0164	.0144	.0020	.32	.0045	.0001	.26	2.0
39474	March 31	V. slight.	Slight.	.08	.15	Faintly vegetable.	Distinctly vegetable.	3.85	1.50	.0010	.0148	.0128	.0020	.30	.0070	.0001	.23	1.8
40008	May 13	V. slight.	Slight.	.06	.11	None.	Faintly vegetable.	3.45	1.15	.0014	.0148	.0136	.0012	.27	.0050	.0000	.25	1.3
40285	June 2	V. slight.	Slight.	.08	.15	Faintly vegetable.	Distinctly vegetable	4.25	1.15	.0008	.0138	.0124	.0014	.27	.0050	.0000	.25	1.8
40824	June 30	V. slight.	V. slight.	.06	.11	Faintly vegetable.	Distinctly vegetable.	3.75	1.30	.0014	.0150	.0122	.0028	.30	.0020	.0000	.25	1.8
41441	Aug. 4	None.	V. slight.	.04	.08	None.	None.	3.75	0.90	.0008	.0138	.0126	.0012	.28	.0000	.0000	.34	1.7
42085	Sept. 8	V. slight.	Slight.	.05	.09	Faintly vegetable.	Distinctly vegetable.	3.75	1.75	.0020	.0158	.0142	.0016	.29	.0000	.0000	.24	1.7
42491	Sept. 29	V. slight.	V. slight.	.05	.09	Faintly vegetable.	Distinctly vegetable.	3.85	1.10	.0006	.0128	.0120	.0008	.28	.0020	.0000	.27	1.4
42990	Nov. 3	V. slight.	V. slight.	.09	.17	Faintly vegetable.	Distinctly vegetable	3.50	1.25	.0012	.0136	.0118	.0018	.30	.0000	.0000	.19	1.6
43372	Dec. 2	None.	V. slight.	.08	.15	Faintly vegetable.	Distinctly vegetable.	3.60	1.50	.0012	.0136	.0112	.0024	.31	.0010	.0000	.25	1.6
Av..	....	....	....	.07	.13	....	....	3.93	1.33	.0017	.0149	.0132	.0017	.30	.0025	.0000	.26	1.8

NOTE. — The figures given above for analyses of January 1 and March 3, obtained by interpolation, have been substituted for those originally reported, since the latter showed conclusively that the samples consisted largely of melted ice, and were not representative of the water in the pond.

TABLE NO. 28. — *Chemical Examinations of Water from a Faucet at the State House, Boston.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.				Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.		Cold.	Hot.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
				Nessler Standard.	Transformed to Platinum Standard.						Total.	Dissolved.	Suspended.					
	1902.																	
38508	Jan. 1	V. slight.	Slight.	.28	.32	Faintly vegetable.	Distinctly vegetable.	4.00	1.35	.0022	.0150	.0132	.0018	.36	.0170	.0001	.45	1.7
38849	Feb. 4	V. slight.	V. slight.	.34	.35	None.	Faintly vegetable.	4.50	1.50	.0040	.0124	.0122	.0002	.34	.0200	.0000	.53	1.7
39192	March 3	Slight.	Slight.	.31	.34	Faintly vegetable.	Distinctly vegetable.	4.00	1.60	.0022	.0112	.0106	.0006	.22	.0200	.0002	.42	1.0
39465	March 31	V. slight.	Slight.	.27	.31	Faintly vegetable.	Distinctly vegetable.	3.70	1.50	.0016	.0106	.0082	.0024	.26	.0060	.0001	.40	1.0
39892	May 5	V. slight.	Slight.	.24	.29	None.	Faintly vegetable.	3.80	1.50	.0014	.0126	.0110	.0016	.24	.0100	.0001	.32	1.1
40276	June 2	V. slight.	Cons.	.24	.29	Faintly vegetable.	Distinctly vegetable.	4.30	1.75	.0010	.0152	.0110	.0042	.27	.0050	.0000	.35	1.1
40847	July 1	V. slight	V. slight.	.23	.28	Faintly vegetable.	Distinctly vegetable.	3.40	1.25	.0016	.0136	.0124	.0012	.26	.0120	.0000	.38	1.1
41434	Aug. 4	V slight.	Slight.	.23	.28	Faintly vegetable.	Faintly vegetable.	3.65	1.65	.0004	.0164	.0124	.0040	.33	.0070	.0001	.34	1.6
41971	Sept. 2	V. slight.	Slight.	.17	.24	Faintly vegetable.	Distinctly vegetable.	3.75	1.60	.0016	.0164	.0146	.0018	.29	.0030	.0000	.35	1.3
42486	Sept. 29	Slight.	V. slight.	.12	.20	Faintly vegetable.	Distinctly vegetable.	4.00	1.50	.0008	.0136	.0120	.0016	.31	.0020	.0000	.35	1.4
42988	Nov. 3	V. slight.	Slight.	.27	.31	Faintly vegetable.	Distinctly vegetable.	3.85	1.75	.0008	.0150	.0126	.0024	.33	.0010	.0000	.40	1.1
43342	Dec. 1	V. slight.	Slight.	.37	.37	Faintly vegetable.	Distinctly vegetable.	4.25	1.75	.0020	.0144	.0118	.0026	.29	.0070	.0000	.50	1.6
Av...	....	....	....	.26	.30	....	....	3.93	1.56	.0016	.0139	.0119	.0020	.29	.0092	.0000	.40	1.3

TABLE No. 29. — *Averages of Examinations of Water from Various Parts of the Metropolitan Water Works.* — *1902.*

[Parts per 100,000.]

LOCALITY.	Color.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
	Nessler Standard.	Platinum Standard.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
Quinepoxet River, Holden,	.45	.42	3.57	1.65	.0026	.0223	.0175	.0048	.30	.0050	.0001	.65	0.5
Stillwater River, Sterling,	.39	.38	3.29	1.46	.0021	.0163	.0144	.0019	.16	.0020	.0000	.58	0.6
Nashua River, Clinton,	.38	.38	3.62	1.49	.0025	.0190	.0161	.0029	.22	.0050	.0001	.50	0.9
Marlborough (Walker's) Brook,	.59	.51	15.10	4.76	.0808	.0548	.0302	.0246	2.16	.1261	.0034	.73	5.0
Marlborough Brook filter beds, effluent,	.14	.21	11.55	–	.0140	.0115	–	–	1.54	.1917	.0004	.25	4.0
Sudbury Reservoir, surface,*	.24	.29	3.73	1.39	.0026	.0145	.0122	.0023	.24	.0084	.0001	.40	1.2
Sudbury Reservoir, mid-depth,*	.24	.29	3.75	1.39	.0033	.0141	.0121	.0020	.25	.0091	.0001	.40	1.2
Sudbury Reservoir, bottom,*	.25	.29	3.77	1.38	.0040	.0136	.0121	.0015	.25	.0097	.0001	.40	1.2
Framingham Reservoir No. 3, near dam,	.23	.28	3.80	1.42	.0026	.0159	.0132	.0027	.28	.0076	.0001	.40	1.3
Hopkinton Reservoir, influent,	1.54	1.18	5.72	3.14	.0051	.0329	.0306	.0023	.38	.0065	.0001	1.34	1.2
Hopkinton Reservoir, surface,	.53	.48	3.55	1.82	.0034	.0204	.0173	.0031	.30	.0045	.0000	.66	0.8
Hopkinton Reservoir, bottom,	.57	.50	3.62	1.81	.0053	.0186	.0163	.0023	.29	.0042	.0000	.65	0.7
Ashland Reservoir, influent,	1.30	1.02	4.60	2.70	.0033	.0315	.0283	.0032	.24	.0030	.0000	1.21	1.0
Ashland Reservoir, surface,	.48	.45	2.94	1.52	.0016	.0187	.0167	.0020	.20	.0023	.0000	.61	0.5
Ashland Reservoir, bottom,	.62	.53	3.41	1.69	.0024	.0201	.0188	.0013	.24	.0043	.0000	.69	0.9
Framingham Reservoir No. 2, influent,	.89	.69	4.22	2.27	.0027	.0236	.0211	.0025	.28	.0028	.0000	.93	0.9
Framingham Reservoir No. 2, near dam,	.71	.58	3.81	1.97	.0030	.0215	.0191	.0024	.27	.0047	.0000	.83	0.9
Lake Cochituate,	.25	.29	4.77	1.90	.0028	.0192	.0161	.0031	.42	.0100	.0002	.46	1.9
Terminal chamber, Sudbury Aqueduct,	.27	.31	3.79	1.42	.0027	.0156	.0137	.0019	.26	.0091	.0001	.41	1.3
Spot Pond,	.07	.13	3.93	1.33	.0017	.0149	.0132	.0017	.30	.0025	.0000	.26	1.8
Tap at State House,	.26	.30	3.93	1.56	.0016	.0139	.0119	.0020	.29	.0092	.0000	.40	1.3

* These examinations were made weekly.

TABLE No. 30. — *Chemical Examinations of Water from a Faucet in Boston, from 1888 to 1902.*

[Parts per 100,000.]

YEARS.	Color. Nessler Standard.	Color. Platinum Standard.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
1888, . .	.38	.38	4.94	1.53	.0012	.0215	-	-	.40	.0183	.0002	-	-
1889, . .	.51	.46	4.71	1.43	.0005	.0199	.0176	.0023	.42	.0272	.0002	-	-
1890, . .	.35	.36	4.70	1.25	.0003	.0169	.0148	.0021	.42	.0241	.0001	-	2.2
1891, . .	.37	.38	4.39	1.63	.0005	.0161	.0136	.0025	.37	.0227	.0001	-	1.7
1892, . .	.37	.37	4.70	1.67	.0007	.0168	.0138	.0030	.41	.0210	.0001	-	1.9
1893, . .	.61	.53	4.54	1.84	.0010	.0174	.0147	.0027	.38	.0143	.0001	.60	1.8
1894, . .	.69	.58	4.64	1.83	.0006	.0169	.0150	.0019	.41	.0106	.0001	.63	1.7
1895, . .	.72	.59	4.90	2.02	.0006	.0197	.0175	.0022	.40	.0171	.0001	.69	0.7
1896, . .	.49	.45	4.29	1.67	.0005	.0165	.0142	.0023	.37	.0155	.0001	.56	1.4
1897, . .	.65	.55	4.82	1.84	.0009	.0193	.0177	.0016	.40	.0137	.0001	.64	1.6
1898, . .	.41	.40	4.19	1.60	.0008	.0152	.0136	.0016	.29	.0097	.0001	.44	1.4
1899, . .	.23	.28	3.70	1.30	.0006	.0136	.0122	.0014	.24	.0137	.0001	.35	1.1
1900, . .	.24	.29	3.80	1.20	.0012	.0157	.0139	.0018	.25	.0076	.0001	.38	1.3
1901, . .	.24	.29	4.43	1.64	.0013	.0158	.0142	.0016	.30	.0173	.0001	.42	1.7
1902, . .	.26	.30	3.93	1.56	.0016	.0139	.0119	.0020	.29	.0092	.0000	.40	1.3

TABLE No. 31. — *Colors of Water from Various Parts of the Metropolitan Water Works, 1902. (Means of Weekly Determinations.)*

[Platinum standard.]

MONTHS.	Nashua River. Surface.	Sudbury Reservoir. Surface.	Sudbury Reservoir. Mid-depth.	Sudbury Reservoir. Bottom.	Sudbury Reservoir. End of Open Channel.	Framingham Reservoir No. 3. Surface.	Framingham Reservoir No. 3. Mid-depth.	Framingham Reservoir No. 3. Bottom.	Whitehall Reservoir. Surface.
January, ...	0.40	0.45	0.42	0.41	0.50	0.40	0.39	0.40	0.53
February, ...	0.31	0.40	0.39	0.40	0.32	0.40	0.40	0.40	0.58
March, ...	0.44	0.22	0.32	0.33	0.68	0.37	0.37	0.37	0.50
April, ...	0.38	0.30	0.30	0.30	0.59	0.31	0.31	0.31	0.38
May, ...	0.44	0.31	0.31	0.31	0.49	0.32	0.32	0.33	0.44
June, ...	0.47	0.32	0.32	0.32	0.46	0.32	0.32	0.33	0.52
July, ...	0.45	0.24	0.25	0.26	0.42	0.25	0.26	0.29	0.49
August, ...	0.51	0.20	0.20	0.22	0.50	0.23	0.24	0.25	0.45
September, ...	0.43	0.18	0.19	0.21	0.41	0.20	0.21	0.23	0.42
October, ...	0.56	0.20	0.20	0.22	0.58	0.23	0.23	0.22	0.43
November, ...	0.63	0.40	0.40	0.44	0.61	0.35	0.35	0.35	0.47
December, ...	0.46	0.49	0.47	0.46	0.53	0.44	0.44	0.44	0.46
Mean, ...	0.46	0.31	0.31	0.32	0.51	0.32	0.32	0.33	0.47

TABLE No. 31 — *Continued.*

[Platinum standard.]

MONTHS.	Hopkinton Reservoir.				Ashland Reservoir.				Framingham Reservoir No. 2.			
	Surface.	Mid-depth	Bottom.	Inlet.	Surface.	Mid-depth.	Bottom.	Inlet.	Surface.	Mid-depth.	Bottom.	Inlet.
January,	0.75	0.71	0.72	1.00	0.78	0.71	0.72	0.86	0.67	0.68	0.68	0.66
February,	0.70	0.71	0.73	1.31	0.59	0.71	0.71	0.90	0.64	0.64	0.64	0.64
March,	0.59	0.61	0.61	0.73	0.63	0.63	0.64	0.68	0.54	0.54	0.54	0.54
April,	0.58	0.58	0.58	1.19	0.58	0.58	0.58	1.06	0.64	0.65	0.65	0.71
May,	0.59	0.60	0.60	1.89	0.65	0.64	0.63	1.39	0.80	0.80	0.80	0.95
June,	0.58	0.58	0.58	2.07	0.65	0.63	0.62	1.63	0.80	0.80	0.80	0.86
July,	0.53	0.53	0.53	1.80	0.59	0.59	0.59	1.08	0.65	0.66	0.69	0.53
August,	0.47	0.48	0.67	1.76	0.51	0.54	0.63	1.16	0.49	0.50	0.55	0.54
September,	0.44	0.45	1.26	1.72	0.47	0.49	0.67	0.73	0.46	0.47	0.49	0.57
October,	0.51	0.51	1.12	1.98	0.54	0.54	0.68	1.23	0.88	0.88	0.88	1.10
November,	0.57	0.57	0.57	1.65	0.63	0.63	0.63	1.75	1.09	1.09	1.10	1.21
December,	0.38	0.42	0.48	1.30	0.59	0.59	0.59	1.31	0.96	1.02	1.05	0.85
Mean,	0.56	0.56	0.70	1.53	0.60	0.60	0.64	1.15	0.72	0.73	0.74	0.76

[Platinum standard.]

MONTHS.	Framingham Reservoir No. 1.	Lake Cochituate.				Spot Pond.			Fells Reservoir.	Bear Hill Reservoir.
	Surface.	Surface.	Mid-depth	Bottom.	Influent Streams.*	Surface.	Mid-depth.	Bottom.	Gate-house.	Gate-house.
January,	0.68	0.37	0.33	0.40	0.73	0.13	0.13	0.13	0.27	-
February,	0.61	0.36	0.36	0.47	0.57	0.12	0.12	0.14	0.15	-
March,	0.55	0.42	0.41	0.48	0.62	0.10	0.13	0.15	0.22	-
April,	0.61	0.40	0.40	0.42	0.81	0.13	0.13	0.14	0.19	-
May,	0.66	0.33	0.35	0.46	0.98	0.14	0.14	0.14	0.20	-
June,	0.74	0.31	0.33	0.75	0.96	0.13	0.14	0.15	0.20	-
July,	0.62	0.27	0.32	0.95	0.84	0.13	0.14	0.15	0.20	0.28
August,	0.52	0.23	0.34	1.10	0.68	0.13	0.14	0.17	0.19	0.21
September,	0.46	0.22	0.36	1.33	0.67	0.14	0.14	0.17	0.17	0.19
October,	0.61	0.22	0.30	1.72	0.99	0.14	0.15	0.18	0.15	0.15
November,	0.65	0.34	0.34	1.28	1.00	0.16	0.17	0.18	0.17	0.20
December,	0.95	0.32	0.34	0.37	0.74	0.16	0.17	0.20	0.20	0.22
Mean,	0.64	0.32	0.35	0.81	0.80	0.13	0.14	0.16	0.19	0.21

* The colors given in this column represent the combined colors of the water of the four principal feeders. The color of each is determined monthly, and due weight is given, in combining the results, to the size of the streams.

TABLE No. 31 — *Concluded.*

[Platinum standard.]

MONTHS.	Chestnut Hill Reservoir. Surface.	Mid depth.	Bottom.	Inlet (Sudbury Aqueduct)	Inlet (Cochituate Aqueduct.	Effluent Gatehouse No. 2.	Tap at No. 244 Boylston Street, Boston.	Tap at No. 1 Ashburton Place, Boston.
January,	–	–	–	0.37	0.31	0.36	0.36	0.36
February,	–	–	–	0.39	–	0.38	0.38	0.36
March,	–	–	–	0.36	0.38	0.33	0.34	0.34
April,	0.28	0.29	0.29	0.30	0.32	0.29	0.29	0.29
May,	0.30	0.30	0.29	0.34	0.28	0.31	0.32	0.32
June,	0.32	0.33	0.32	0.36	0.22	0.34	0.36	0.40
July,	0.30	0.30	0.41	0.34	0.26	0.31	0.32	0.31
August,	0.26	0.27	0.49	0.30	0.22	0.26	0.28	0.28
September,	0.26	0.26	0.51	0.28	0.23	0.26	0.27	0.27
October,	0.29	0.30	0.31	0.36	0.20	0.30	0.31	0.30
November,	0.35	0.35	0.37	0.39	0.26	0.35	0.36	0.37
December,	–	–	–	0.42	0.31	0.39	0.41	0.42
Mean,	0.30	0.30	0.37	0.35	0.27	0.32	0.33	0.34

TABLE No. 32. — *Temperatures of Water from Various Parts of the Metropolitan Water Works, 1902. (Means of Weekly Determinations.)*

[The temperatures are taken at the same place and time as the samples for microscopical examination; the depth given for each reservoir is the depth from high-water mark where the temperatures are taken.]

[Degrees Fahrenheit.]

MONTHS.	Nashua River.	Sudbury Reservoir (Depth at Place of Observation 54.5 Feet).				Framingham Reservoir No. 3 (Depth at Place of Observation 20.5 Feet).			Hopkinton Reservoir (Depth at Place of Observation 54.3 Feet).		
	Surface.	Surface.	Mid-depth.	Bottom.	End of Open Channel.	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth.	Bottom.
January,	32.8	33.4	34.3	36.1	31.8	34.9	35.2	35.4	34.1	36.0	36.9
February,	32.1	33.7	35.2	37.0	32.5	34.5	35.2	35.7	34.6	37.0	38.1
March,	37.9	36.2	36.7	37.6	37.8	38.4	38.7	38.8	41.6	41.6	41.8
April,	48.6	46.4	45.6	45.2	49.3	48.4	48.3	48.0	44.9	43.5	42.9
May,	61.0	58.3	55.2	52.7	59.6	58.9	58.5	57.7	56.7	51.7	48.1
June,	68.1	67.6	64.4	62.5	68.9	67.4	66.7	66.1	65.3	54.6	50.0
July,	69.9	70.9	68.6	67.6	70.6	71.6	70.3	69.4	70.1	60.9	51.6
August,	71.8	71.7	68.8	66.9	71.0	71.2	70.5	69.8	71.4	65.2	50.4
September,	67.4	67.4	66.5	65.6	66.4	67.7	67.5	67.5	67.2	65.3	50.2
October,	56.0	58.4	58.5	58.6	55.4	56.3	56.8	57.2	57.7	57.7	52.9
November,	45.7	47.9	48.0	48.0	44.4	47.2	47.6	47.8	46.3	46.3	48.0
December,	36.2	35.9	36.9	37.6	34.4	36.0	36.7	37.6	45.0	44.3	44.2
Mean,	52.3	52.3	51.6	51.3	51.8	52.7	52.7	52.6	52.9	50.8	46.9

TABLE No. 32 — *Concluded.*

[Degrees Fahrenheit.]

MONTHS.	Ashland Reservoir (Depth at Place of Observation 40.7 Feet).			Framingham Reservoir No 2 (Depth at Place of Observation 20.5 Feet).			Lake Cochituate (Depth at Place of Observation 62.0 Feet).			Whitehall Reservoir.
	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth	Bottom	Surface.
January,	33.2	35.8	38.2	32.9	33.4	33.8	33.9	35.8	37.1	36.6
February,	34.6	36.5	38.8	33.7	34.3	34.8	35.8	36.6	37.7	37.5
March,	37.9	37.9	38.3	38.5	38.8	39.0	37.1	37.3	37.9	40.3
April,	47.8	46.8	46.2	49.9	49.8	50.4	45.8	43.6	42.2	49.4
May,	60.3	56.0	50.0	60.6	59.8	59.1	59.0	48.6	43.0	60.9
June,	69.4	59.0	51.3	69.4	67.8	66.7	68.9	49.5	43.5	67.4
July,	70.6	63.6	53.0	72.0	70.7	69.8	71.0	49.0	43.6	70.0
August,	71.5	63.3	50.0	71.3	69.7	69.1	72.4	49.0	43.7	72.3
September,	67.0	61.7	50.0	67.1	66.8	66.5	67.9	49.1	43.7	66.4
October,	58.0	58.0	54.4	55.0	55.6	56.0	57.9	52.0	46.1	56.1
November,	48.4	48.8	49.0	46.4	47.0	47.3	48.5	48.0	45.0	46.7
December,	39.0	39.9	40.4	35.1	35.7	36.5	38.4	39.1	38.8	35.2
Mean,	53.1	50.6	46.6	52.7	52.5	52.4	53.1	44.8	41.9	53.2

[Degrees Fahrenheit.]

MONTHS.	Spot Pond (Depth at Place of Observation 28.0 Feet).			Chestnut Hill Reservoir (Depth at Place of Observation 26.0 Feet).						Tap at No. 244 Boylston Street, Boston.	Tap at No. 1 Ashburton Place, Boston.
	Surface.	Mid depth.	Bottom.	Surface.	Mid-depth.	Bottom.	Inlet (Sudbury Aqueduct).	Inlet (Cochituate Aqueduct).	Effluent Gate-house No. 2.		
January,	34.4	35.8	36.6	–	–	–	36.0	39.2	35.8	37.2	38.4
February,	35.5	37.7	38.3	–	–	–	36.2	–	35.6	36.6	37.1
March,	38.0	40.0	40.2	–	–	–	39.0	39.1	40.1	40.0	40.9
April,	47.0	47.5	47.5	–	–	–	47.4	45.8	48.1	48.5	49.0
May,	58.3	56.9	55.5	57.4	56.4	52.8	57.8	56.4	58.8	58.6	59.0
June,	65.7	65.0	60.5	65.3	59.9	56.2	65.2	60.3	65.8	65.8	66.1
July,	69.5	69.1	66.9	69.3	66.6	59.3	68.5	69.6	69.5	68.8	69.3
August,	71.8	70.8	68.5	72.8	70.4	60.3	70.6	72.0	71.6	71.0	71.4
September,	68.0	67.7	67.3	68.5	67.0	62.3	67.8	67.7	68.2	68.0	68.4
October,	61.0	61.4	61.4	57.0	57.3	57.2	58.1	58.5	58.3	59.4	59.4
November,	51.0	51.1	51.1	47.3	47.0	46.0	48.0	49.7	48.3	50.1	50.4
December,	35.0	36.2	36.4	–	–	–	37.9	37.6	37.1	39.6	40.1
Mean,	52.9	53.3	52.5	62.5	60.7	56.3	52.7	54.2	53.1	53.6	54.1

TABLE No. 33. — *Temperatures of the Air at Three Stations on the Metropolitan Water Works, 1902.*

[Degrees Fahrenheit.]

MONTHS.	Chestnut Hill Reservoir.			Framingham.			Clinton.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
January,	52.0	2.0	24.5	55.0	0.0	24.2	56.0	2.0	22.5
February,	52.5	8.0	27.8	50.0	0.0	25.1	51.5	7.5	24.5
March,	68.0	18.0	43.4	68.0	13.0	43.5	66.5	21.0	40.3
April,	77.0	29.0	48.3	80.0	28.0	48.4	81.5	27.0	46.5
May,	89.0	33.0	58.0	89.0	33.0	58.0	87.0	31.0	56.9
June,	92.0	45.0	65.6	92.0	43.0	65.1	88.0	44.0	63.9
July,	92.0	48.5	68.7	92.0	47.0	68.2	88.0	48.5	67.7
August,	89.5	47.0	67.8	87.0	44.0	67.0	87.0	37.5	66.2
September,	90.5	39.0	62.5	87.0	36.0	60.9	87.0	38.0	60.5
October,	75.0	26.0	54.2	78.0	22.0	50.8	72.5	21.5	50.6
November,	68.0	23.0	45.7	69.0	19.0	42.9	66.5	24.0	41.9
December,	55.0	—10.0	27.4	54.0	—14.0	25.5	50.5	—12.0	24.3
Averages,	-	-	49.5	-	-	48.3	-	-	47.2

Table No. 34. — *Table showing Length of Main Lines of Water Pipes and Connections owned and operated by Metropolitan Water and Sewerage Board and Number of Valves set in Same.*

	Diameter of Pipes in Inches.													Totals.
	60	48	42	36	30	24	20	16	14	12	10	8	6	
Length owned and operated January 1, 1902 (feet),	307	124,163	8,075	46,512	26,907	46,604	56,781	53,984	26	14,151	530	1,389	740	380,169
Gate valves in same,	-	33	-	37	27	33	33	47	1	46	7	4	12	280
Air valves in same,	-	67	3	33	4	19	34	28	-	4	-	-	-	192
Length laid or relaid during 1902 (feet),	8,258	36,794	-	19	3	15	376	1,335	-	8,988	110	208	63	56,169
Gate valves in same,	-	7	-	-	-	-	4	8	-	15	6	8	1	49
Air valves in same,	3	25	-	2	-	-	-	1	-	5	-	-	-	36
Length abandoned during 1902 (feet),	3	-	-	-	-	67	66	1,112	-	1,612	-	12	5	2,877
Gate valves in same,	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Air valves in same,	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total length owned and operated January 1, 1903 (feet),	8,562	160,957	8,075	46,531	26,910	46,552	57,091	54,207	26	21,527	640	1,585	798	433,461*
Gate valves in same,	-	40	-	37	27	33	37	55	1	60	13	12	13	328
Air valves in same,	3	92	3	35	4	19	34	29	-	9	-	-	-	228

* 82.09 miles.

TABLE No. 35. — *Statement of Cast-iron Hydrant, Blow-off and Drain Pipes laid to January 1, 1903, owned and operated by Metropolitan Water and Sewerage Board.*

	Diameter of Pipes in Inches.								Totals.
	24	20	16	12	10	8	6	4	
Length laid to January 1, 1902 (feet),	352	-	2,110	3,490	107	93	2,604	979	9,735
Length laid during 1902 (feet),	-	258	88	703	70	62	40	187	1,408
Length abandoned during 1902 (feet),	-	-	-	-	4	-	-	16	20
Total length in use January 1, 1903 (feet),	352	258	2,198	4,193	173	155	2,644	1,150	11,123
Valves set to January 1, 1902,	-	-	16	57	1	-	53	34	161
Valves set during 1902,	-	-	1	13	-	-	-	6	20
Valves abandoned during 1902,	-	-	-	-	-	-	-	1	1
Total valves in use January 1, 1903,	-	-	17	70	1	-	53	39	180

TABLE No. 36. — *Length of Water Pipes, Four Inches in Diameter and Larger, in the Several Cities and Towns supplied by the Metropolitan Water Works.*

By whom owned.	Inches.																			Total.	
	60	48	42	40	36	30	28	24	20	18	16	14	12	10	8	7	6	5	4	Feet.	Miles.
Metropolitan Water Works.	8,562	160,957	8,075	-	46,531	26,910	-	46,552	57,091	-	54,207	26	21,527	640	1,585	-	798	-	-	433,461	82.09
Boston,	-	33,671	16,813	23,104	39,984	86,434	244	79,751	93,896	-	185,240	-	1,123,429	108,982	560,431	-	1,375,149	-	90,282	3,817,410	722.99
Somerville,	-	-	-	-	-	-	-	-	3,596	387	2,071	8,037	75,984	45,222	88,375	-	191,168	-	20,680	435,520	82.48
Malden,	-	-	-	-	-	-	-	-	-	-	-	12,174	64,770	20,511	67,782	-	189,112	-	78,696	433,045	82.02
Chelsea,	-	-	-	-	-	-	-	-	-	-	2,380	-	-	38,001	25,403	-	128,132	-	10,377	204,293	38.69
Quincy,	-	-	-	-	-	-	-	-	2,679	-	19,813	-	21,230	30,531	81,584	994	192,581	948	91,763	442,123	83.74
Everett,	-	-	-	-	-	-	-	2,484	2,900	-	2,233	206	5,570	33,483	20,716	-	121,672	-	32,795	222,059	42.06
Medford,	-	-	-	-	-	-	-	-	673	-	6,775	9,585	25,614	29,844	65,295	-	78,960	-	49,322	266,068	50.39
Melrose,	-	-	-	-	-	-	-	-	-	-	5,200	2,920	16,253	6,010	21,424	-	101,927	-	81,316	235,050	44.52
Revere,*	-	-	-	-	-	-	-	-	-	-	22,650	5,700	7,380	8,550	14,532	-	59,561	-	66,300	184,673	34.98
Watertown,	-	-	-	-	-	-	-	-	-	-	400	12,127	5,959	4,169	19,261	-	104,061	-	13,239	159,216	30.15
Winthrop,*	-	-	-	-	-	-	-	-	-	-	-	-	4,000	4,800	19,320	-	22,200	-	69,412	119,732	22.68
Belmont,	-	-	-	-	-	-	-	-	-	-	-	-	2,161	11,102	12,896	-	67,871	-	283	94,313	17.86
Nahant,	-	-	-	-	-	-	-	-	-	-	-	-	150	11,550	4,850	-	32,740	-	34,725	84,015	15.91
Arlington,	-	-	-	-	-	-	-	-	-	-	-	-	31,618	21,106	22,558	-	73,414	-	32,520	181,216	34.32
Swampscott,	-	-	-	-	-	-	-	-	-	-	-	-	12,072	12,059	14,324	-	43,603	-	9,014	91,072	17.25
Stoneham,	-	-	-	-	-	-	-	-	-	-	-	-	4,350	3,575	2,275	-	88,800	-	6,050	105,050	19.90
Milton,	-	-	-	-	-	-	-	-	-	-	103	44	22,331	16,630	28,644	-	104,988	-	12,312	185,052	35.05
Total feet,	8,562	194,628	24,888	23,104	86,515	113,344	244	128,787	160,835	387	301,072	50,819	1,444,398	406,765	1,071,255	994	2,976,737	948	699,086	7,693,368	-
Total miles,	1.62	36.86	4.71	4.38	16.39	21.47	.05	24.39	30.46	.07	57.02	9.62	273.56	77.04	202.89	.19	563.78	.18	132.40	-	1,457.08

* Pipes owned by Revere Water Company.

Table No. 37. — *Number of Service Pipes, Meters and Fire Hydrants in the Several Cities and Towns supplied by the Metropolitan Water Works.*

CITY OR TOWN.	Services.	Meters.	Fire Hydrants.
Boston,	89,384	4,617	7,785
Somerville,	10,710	271	955
Malden,	6,700	4,245	401
Chelsea,	6,257	113	290
Quincy,	4,850	152	607
Everett,	4,670	49	484
Medford,	4,039	124	467
Melrose,	3,221	95	273
Revere,	2,261	28	126
Watertown,	1,692	1,515	313
Winthrop,	1,747	9	112
Belmont,	621	621	141
Nahant,	462	43	62
Arlington,	1,700	94	339
Swampscott,	1,055	–	217
Stoneham,	1,157	19	93
Milton,	1,078	1,078	268
Totals,	141,604	13,073	12,933

Appendix No. 4.

Summary of Statistics for the Year 1902.

The Metropolitan Water Works supply the Metropolitan Water District, which includes the following cities and towns: —

CITIES AND TOWNS.	Population, Census of 1900.	Estimated Population, May 1, 1902.
Boston,	560,892	585,600
Somerville,	61,643	65,600
Chelsea,	34,072	35,300
Malden,	33,664	35,800
Newton,*	33,587	36,300
Everett,	24,336	26,700
Quincy,	23,899	25,800
Medford,	18,244	20,100
Hyde Park,*	13,244	13,900
Melrose,	12,962	13,600
Revere,	10,395	11,900
Watertown,	9,706	10,500
Arlington,	8,603	9,400
Stoneham,	6,197	6,300
Winthrop,	6,058	6,900
Belmont,	3,929	4,500
Nahant,	1,152	1,200
Total population of Metropolitan Water District,	862,583	909,400
Milton,†	6,578	7,100
Swampscott,†	4,548	4,900
Saugus,‡	158	200

* No water supplied to these places during the year from Metropolitan Water Works.

† Not in the Metropolitan Water District, but have been supplied with water from the Metropolitan Water Works.

‡ Only a small portion of Saugus is supplied with water.

Sources of Supply.

SOURCE.	Area of Watershed (Square Miles).	Remarks.
Lake Cochituate,	18.87	Original works built in 1848.
Sudbury River,	75.20	Original works built in 1872-78.
Nashua River,	118.23	Works begun in 1895; not finished.

Mode of Supply.

Pumping to reservoirs.

Pumping.

Chestnut Hill High-service Station:—

Builders of pumping machinery, Holly Manufacturing Company, Quintard Iron Works and E P. Allis Company.

Description of coal used: Bituminous; Georges Creek Cumberland and Loyal Hanna Sonman Shaft; anthracite coal screenings. Price per gross ton in bins: $4.34 to $8.40; screenings, $2.24. Average price per gross ton, $4.85. Per cent. ashes, 10.8.

Chestnut Hill Low-service Station:—

Builders of pumping machinery, Holly Manufacturing Company.

Description of coal used: Bituminous; Georges Creek Cumberland and Loyal Hanna Sonman Shaft. Price per gross ton in bins, $4.34 to $8.40. Average price per gross ton, $4.95. Per cent. ashes, 9.8.

Spot Pond Station:—

Builders of pumping machinery, Geo. F. Blake Manufacturing Company and Holly Manufacturing Company.

Description of coal used: Bituminous; Georges Creek Cumberland and Loyal Hanna Sonman Shaft; anthracite buckwheat. Price per gross ton in bins, $4.25 to $6.72. Average price per gross ton, $5.26. Per cent. ashes, 10.5.

	Chestnut Hill High-service Station.		
	Engine No 1.	Engine No. 3.	Engine No. 4.
Coal consumed for year (pounds),	380,417	443,134	8,078,166
Cost of pumping, figured on pumping station expenses,	$2,547.77	$2,344.16	$39,385.36
Total pumpage for year (million gallons),	273.90	503.39	10,118.61
Average dynamic head,	119.99	123.70	128.43
Gallons pumped per pound of coal,	720.00	1,135.98	1,252.59
Duty on basis of plunger displacement,	75,130,000	120,700,000	136,010,000
Cost per million gallons raised to reservoir,	$9.302	$4.657	$3.892
Cost per million gallons raised one foot,	.078	.038	.030

	Chestnut Hill Low-service Station. Engines Nos. 5, 6 and 7.	Spot Pond Station. Engine No. 9.
Coal consumed for year (pounds),	8,275,464	2,267,456
Cost of pumping, figured on pumping station expenses,	$37,885.33	$13,162.90
Total pumpage for year (million gallons),	27,941.95	2,919.01
Average dynamic head,	42.48	123.73
Gallons pumped per pound of coal,	3,376.48	1,287.35
Duty on basis of plunger displacement,	121,340,000	134,880,000
Cost per million gallons raised to reservoir,	$1.356	$4.509
Cost per million gallons raised one foot,	.032	.036

Consumption.

Estimated total population of the eighteen cities and towns supplied wholly or partially during the year 1902 (yearly average),	874,200
Total consumption, gallons,	39,152,660,000
Furnished from Metropolitan Water Works sources, gallons,	39,122,640,000
Furnished from local sources, gallons,	30,020,000
Average daily consumption, gallons,	107,268,000
Gallons per day each inhabitant,	122.7

Distribution.

	Owned and operated by Metropolitan Water and Sewerage Board.	Total in District supplied by Metropolitan Water Works.
Kind of pipe used,	-*	-†
Sizes,	60 to 6 inch.	60 to 4 inch.
Extension less length abandoned, miles,	10.09	60.59
Length in use, miles,	82.09	1,457.1
Stop gates added,	48	-
Stop gates now in use,	328	-
Service pipes added,	-	3,064
Service pipes now in use,	-	141,604
Meters added,	-	2,043
Meters now in use,	-	13,073
Fire hydrants added,	-	654
Fire hydrants now in use,	-	12,933

* Cast-iron and cement-lined wrought iron. † Cast-iron, cement-lined wrought iron and kalamine.

APPENDIX No. 5.

LEGISLATION OF THE YEAR 1902 AFFECTING THE METROPOLITAN WATER AND SEWERAGE BOARD.

ACTS.

[CHAPTER 13.]

AN ACT MAKING AN APPROPRIATION FOR OPERATING THE SOUTH METROPOLITAN SYSTEM OF SEWAGE DISPOSAL.

Be it enacted, etc., as follows:

South metropolitan system of sewage disposal.

SECTION 1. A sum not exceeding ninety-three thousand six hundred and sixty-six dollars is hereby appropriated, to be paid out of the treasury of the Commonwealth from the ordinary revenue, for the maintenance and operation of the south metropolitan system of sewage disposal, comprising a part of Boston, the cities of Newton, Quincy and Waltham, and the towns of Brookline, Watertown, Dedham, Hyde Park and Milton, during the year ending on the thirty-first day of December, nineteen hundred and two.

SECTION 2. This act shall take effect upon its passage. [*Approved January 27, 1902.*

[CHAPTER 51.]

AN ACT MAKING AN APPROPRIATION FOR OPERATING THE NORTH METROPOLITAN SYSTEM OF SEWERAGE.

Be it enacted, etc., as follows:

North Metropolitan System of sewerage.

SECTION 1. A sum not exceeding one hundred and three thousand four hundred dollars is hereby appropriated, to be paid out of the treasury of the Commonwealth from the ordinary revenue, for the maintenance and operation of the system of sewage disposal for the cities of Boston, Cambridge, Somerville, Malden, Chelsea, Woburn, Medford, Melrose and Everett, and the towns of Stoneham, Winchester, Arlington and Bel-

mont, known as the North Metropolitan System, during the year ending on the thirty-first day of December, nineteen hundred and two.

SECTION 2. This act shall take effect upon its passage. [*Approved January 31, 1902.*

[CHAPTER 101.]

AN ACT TO FIX THE TIME WHEN PROPERTY SHALL BE DEEMED TO BE TAKEN FOR THE METROPOLITAN SEWERAGE WORKS.

Be it enacted, etc., as follows:

Description of property to be recorded, etc.

SECTION 1. The metropolitan water and sewerage board, in order hereafter to take any property by right of eminent domain for the metropolitan sewerage works, shall sign and cause to be recorded in the registry of deeds for the county and district in which the property to be taken is situated, a statement containing a description thereof, as certain as is required in a common conveyance of land, and stating that the same is taken for the metropolitan sewerage works; and upon such recording the rights, easements and other property described in such statement shall be taken for the Commonwealth for the purposes of the metropolitan sewerage works. Said board, after it has so taken any property under the right of eminent domain, shall notify the owner thereof, and upon his request, within three years after such taking, shall, within thirty days after such request, furnish him with a description in writing of the land or other property so taken from him.

SECTION 2. This act shall take effect upon its passage. [*Approved February 24, 1902.*

[CHAPTER 189.]

AN ACT TO AUTHORIZE THE METROPOLITAN WATER AND SEWERAGE BOARD TO FURNISH WATER TO COMPANIES OWNING WATER PIPE SYSTEMS IN SECTIONS OF CERTAIN CITIES AND TOWNS.

Be it enacted, etc., as follows:

The metropolitan water and sewerage board may furnish water to certain companies.

SECTION 1. The metropolitan water and sewerage board may from time to time furnish water to any water company which owns the water pipe systems in a section of a city or town, for the supply of such section, although the city or town, or a part of the city or town, is within ten miles of the state house, and the city or town has not been admitted into the metropolitan water district, on payment by the water company of such sum of

money as the said board may determine: *provided, however*, that the sum so determined in any case shall in the opinion of the board exceed the proper proportion of the entire assessment which would be imposed upon the city or town were it a part of the metropolitan district. Proviso.

SECTION 2. This act shall take effect upon its passage. [*Approved March 19, 1902.*

[CHAPTER 307.]

AN ACT TO SUPPLY THE TOWN OF MILTON WITH WATER.

Be it enacted, etc., as follows:

SECTION 1. The town of Milton may supply itself and its inhabitants with water for the extinguishment of fires and for domestic, manufacturing and other purposes; and may establish fountains and hydrants and relocate or discontinue the same, and may regulate the use of such water and fix and collect rates to be paid for the use of the same. Town of Milton may supply itself with water.

. . . .

SECTION 14. The metropolitan water and sewerage board shall on application admit the town of Milton into the metropolitan water district, and shall furnish water to the town on the terms prescribed by chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five and of acts in amendment thereof and in addition thereto, for the cities and towns included in the metropolitan water district, and on payment of such sum of money as said board may determine to be just. Town may be admitted into the metropolitan water district.

. . . .

SECTION 16. This act shall be submitted to the qualified voters of the town of Milton for their acceptance and shall be void unless such voters, voting at a legal meeting called for that purpose in the same manner in which meetings for town elections are called, or at any annual town meeting, shall, within six months after the passage of this act, determine by ballot by a majority vote of those present and voting thereon to accept the same. The warrant for notifying such meeting, if called specially as aforesaid, shall specify when the polls shall be opened for the purpose of voting and when they shall be closed. Question of acceptance to be submitted to voters.

SECTION 17. So much of this act as authorizes the submission of the question of its acceptance to the qualified voters of said town shall take effect upon its passage, but it shall not take further effect until accepted as hereinbefore provided by When to take effect.

the qualified voters of said town; and the number of meetings called for the purpose of voting upon the question of its acceptance shall not exceed three. [*Approved April 17, 1902.*

Accepted by the town of Milton, July 14, 1902.

[Chapter 351.]

An Act to authorize the city of worcester to increase its water supply.

Be it enacted, etc., as follows:

City of Worcester may take certain waters, lands, etc.

Section 1. The city of Worcester is hereby authorized, for the purpose of increasing its water supply, to take by purchase or otherwise, from time to time, and to hold and convey into and through said city the waters of Kendall brook, so-called, at or near the dam of Kendall reservoir, and the waters of Asnebumskit brook, so-called, at or near an elevation of eight hundred feet above mean sea level at Boston, and the waters upon the watershed between said two brooks at or near an elevation of eight hundred feet above mean sea level at Boston, all of said places of taking being in the town of Holden, and also the water in any reservoirs thereon and the waters flowing into and from the same, and all springs and tributaries thereto, and the water rights connected with said sources above said places of taking; and the said city may take existing reservoirs and ponds upon said streams above the points at which it may take the said waters; and may by aqueduct bring the waters so taken directly into the city or through any reservoir and any aqueduct belonging to said city and now existing; and may construct and lay conduits, pipes and other works under or over lands, water courses, railroads, railways, public or private ways and along such ways; and may take by purchase or otherwise and hold in fee or otherwise any lands, dams or structures, easements or rights in land on and around said Kendall brook and reservoir up to an elevation of about eight hundred and fifty feet above said mean sea level, and between said Kendall reservoir and other reservoirs of said city on Tatnuck brook in said Holden, and between said Kendall reservoir and said Asnebumskit brook up to an elevation of about nine hundred and forty feet above said mean sea level; and the said city may build and maintain dams, conduits, canals, water courses, pipes, reservoirs, and such other works as may be deemed necessary for collecting, purifying, storing, discharging, conducting or distributing said waters or preserving the purity thereof.

SECTION 2. The rights herein granted to the city of Worcester shall be subject to the rights granted to the Leicester Water Supply District by chapter two hundred and thirty of the acts of the year eighteen hundred and ninety-five, and if said Leicester Water Supply District shall exercise any rights conferred by said chapter after the taking herein authorized to be made by the city of Worcester the Leicester Water Supply District shall pay to the city of Worcester all damages thereby sustained by it, to be ascertained and determined in the manner and within the time set forth in chapter three hundred and sixty-one of the acts of the year eighteen hundred and seventy-one: *provided*, that from the time when the city of Worcester first diverts the waters of Asnebumskit brook, until the time when an additional source of water supply embracing more than twenty-five square miles of watershed is obtained for the metropolitan water district, the city of Worcester shall not draw water from the sources authorized by this act when water is running to waste past the lowest water works dam of said city on Tatnuck brook; nor, in case the amount of water stored in the reservoirs on Tatnuck brook exceeds one half the total capacity of such reservoirs, shall the city draw water from the sources so authorized when water is running to waste past the lowest water works dam of said city on either Tatnuck brook or Lynde brook; nor, in case the amount of water stored in the reservoirs on Tatnuck brook exceeds three fourths of the total capacity of such reservoirs, shall the city draw water from the sources so authorized when water is running to waste past the lowest water works dam of said city on either Tatnuck brook or Lynde brook or Kettle brook, except that the fact of a waste of water past the Kettle brook dam shall not prevent the drawing of water as aforesaid, if the flow of Kettle brook at the head of the conduit or conduits which convey its water toward the Lynde brook reservoir is in excess of the capacity of such conduit or conduits.

The rights herein granted the city of Worcester to be subject to the rights granted the Leicester Water Supply District, etc.

Proviso.

SECTION 3. The rights, powers and authority given by this act shall be exercised by the city of Worcester from time to time by such officers, servants and agents as the city council may appoint, ordain and direct, and said city shall be entitled to all rights and, except as herein otherwise provided, shall be subject to all the duties and liabilities set forth in chapter three hundred and sixty-one of the acts of the year eighteen hundred and seventy-one.

By whom rights, powers and authority shall be exercised, etc.

SECTION 4. The city shall be liable for all damages to property sustained by the Commonwealth or by any persons by the

Damages.

taking of any land, easements, rights in land, water or water rights as aforesaid, or by the construction of any aqueducts, reservoirs or other works by authority hereof, the same to be ascertained and determined so far as the Commonwealth is concerned in the manner set forth in chapter four hundred and fifty-six of the acts of the year eighteen hundred and ninety-seven, and so far as all other persons are concerned in the manner and within the time set forth in said chapter three hundred and sixty-one of the acts of the year eighteen hundred and seventy-one: *provided, however*, that no application shall be made for the assessment of damages for the taking of any water or water rights or for any injury thereto until the water is actually diverted under authority of this act, and no water shall be diverted until said city has given at least six months notice to all parties by publishing the same in two daily newspapers published in said Worcester, said notice to set forth the fact that said city intends to divert said waters and to fix the exact day upon which it intends to divert the same; and the day so fixed shall be deemed the time of actual diversion, and the application aforesaid may be made within one year after such actual diversion.

Proviso.

Worcester Water Scrip.

SECTION 5. For the purpose of defraying all costs and expenses incident to the acts herein authorized, including the payment for land, water and water rights taken or purchased, the city council shall have authority to borrow from time to time such sums of money as it shall deem necessary, to an amount not exceeding five hundred thousand dollars, and to issue therefor notes, bonds or certificates of indebtedness, to be denominated on the face thereof, Worcester Water Scrip, and subject to the provisions of chapter twenty-seven of the Revised Laws.

SECTION 6. This act shall take effect upon its passage. [*Approved April 29, 1902.*

[CHAPTER 391.]

AN ACT TO PROVIDE FOR THE MEASUREMENT OF WATER SUPPLIED TO CITIES AND TOWNS BY THE METROPOLITAN WATER AND SEWERAGE BOARD.

Be it enacted, etc., as follows:

Water supplied to cities and towns in the metropolitan water district to be measured, etc.

SECTION 1. The metropolitan water and sewerage board is hereby authorized to construct and maintain such works and to provide such other means as it may deem necessary for measuring the water supplied to each of the cities and towns in the

metropolitan water district, and the expenses thereof shall be considered as a part of the expenditure required for the construction and maintenance, respectively, of the metropolitan water works.

Report to be made of quantity of water supplied to each city and town, etc.

SECTION 2. The said board shall report to the next general court the quantity of water supplied to each of the said cities and towns, and shall also report whether water is being used therein unnecessarily or improperly, and shall make recommendations as to the manner in which waste may be prevented and as to the manner in which the consumption of water may be considered in the apportionment among the cities and towns of the annual assessment required for the construction and maintenance of the metropolitan water works.

SECTION 3. This act shall take effect upon its passage. [*Approved May 13, 1902.*

[CHAPTER 392.]

AN ACT TO AUTHORIZE THE TOWN OF NATICK TO ENLARGE AND IMPROVE ITS SYSTEM OF WATER SUPPLY.

Be it enacted, etc., as follows:

Town of Natick may take certain waters, lands, etc.

SECTION 1. The town of Natick, acting by its water commissioners, may enlarge and improve its system of water supply established under the provisions of chapter seventy-six of the acts of the year eighteen hundred and seventy-three and acts in amendment thereof and in addition thereto, and may construct and maintain driven, artesian or other wells upon a parcel of land owned by the town and bounded northerly by Worcester street, easterly by the Saxonville branch of the Boston and Albany railroad, and southerly and westerly by land of the city of Boston; may take, hold and convey into and through said land, and thence through said town, from Lake Cochituate, at any convenient point upon the same, within said town and within one half mile of said parcel of land, sufficient water for the use of said town and its inhabitants for the extinguishment of fires and for domestic and other purposes; may take, for the purposes aforesaid, by purchase or otherwise, and hold any lands, rights of way and easements necessary for laying, constructing and maintaining pipes, aqueducts, water courses, reservoirs, and such other works as may be necessary for holding, conveying and distributing said water or for preserving the purity thereof; and may construct and lay conduits, pipes and other works, under and over any land, water courses,

railroads, railways or public or private ways, in such manner as not unnecessarily to obstruct the same.

. . . .

SECTION 8. This act shall take effect upon its passage. [*Approved May 13, 1902.*

[CHAPTER 438.]

AN ACT TO ESTABLISH A STATE BOARD OF PUBLICATION.

Be it enacted, etc., as follows:

State board of publication, appointment, terms, etc.

SECTION 1. A state board of publication is hereby created, to be composed of three persons from different branches of the public service, who shall be appointed by the governor with the advice and consent of the council. One member shall be appointed for the term of three years, one for the term of two years and one for the term of one year, and thereafter one person shall be appointed annually to serve for the term of three years. No person shall remain a member of the board after his retirement from the branch of the public service from which he was appointed, and the members of the board may be removed at any time by the governor. The members of the board shall receive no compensation for their services, but may expend not more than three hundred dollars annually for such travelling, clerical and other necessary expenses as the governor and council approve; and shall annually in January make a report to the general court, with such recommendations and suggestions as they deem expedient.

To examine and define form, etc., of certain reports, etc.

SECTION 2. It shall be the duty of the said board to examine the annual reports and all special reports and other documents issued by or on behalf of the Commonwealth by any public officer, board or commission, and to define the form and extent thereof, as hereinafter provided. But this act shall not apply to publications issued by the officers of either branch of the general court, or issued under authority of the general court, nor to the regular annual reports of the attorney-general, of the treasurer and receiver general, of the auditor, or of the secretary of the Commonwealth, or to publications prepared by the secretary in conformity with sections one and three of chapter nine of the Revised Laws.

Public officers, etc., may make certain special reports.

SECTION 3. Public officers, boards or commissions may, in addition to their annual reports, make such special reports as shall be deemed by the state board of publication to be of practical utility.

SECTION 4. All boards or commissions before entering upon the preparation of any publication shall submit to the state board of publication careful statements of the scope, and estimates of the size, of such publication. The said board shall have power to determine the number of pages to which any such report may extend, and to determine whether it shall include maps, plans, photogravures, woodcuts or other illustrations; and no such report shall be printed unless it bears the certified approval of the state board of publication.

No report to be printed without the approval of the state board of publication.

SECTION 5. After the first day of April in the year nineteen hundred and three the cost of printing and publishing every such report or other document shall be charged to and paid from the appropriation of the department from which it is issued.

Payment of cost of printing, etc.

SECTION 6. Appeal may be taken from the decision of the state board of publication to the governor and council, whose decision shall be final.

Appeal.

SECTION 7. Sections ten and eleven of chapter one hundred and seven of the Revised Laws, section six of chapter nine of the Revised Laws, and so much of section seven of said chapter as refers to maps, plans, photogravures, woodcuts or other pictorial illustrations, are hereby repealed.

Repeal.

SECTION 8. This act shall take effect upon its passage. [*Approved June 3, 1902.*

[CHAPTER 480.]

AN ACT TO AUTHORIZE THE CITY OF NEWTON TO LAY MAIN DRAINS AND COMMON SEWERS IN A PART OF BEACON STREET IN THE CITY OF BOSTON AND TO MAKE ASSESSMENTS THEREFOR UPON CERTAIN PROPERTY IN THE CITY OF NEWTON.

Be it enacted, etc., as follows:

SECTION 1. The city of Newton is hereby authorized to construct and maintain common sewers and main drains in Beacon street in the city of Boston, from the Newton line easterly to Reservoir lane, so-called, thence through said Reservoir lane and land of the Boston and Albany Railroad Company to connect with the sewers of the town of Brookline: *provided, however*, that such main drains and common sewers shall be laid in said Beacon street and Reservoir lane only with the consent of, and in a manner approved by, the board or officer to whom the care and control of the territory in which the sewer is laid may for the time be committed.

City of Newton may lay main drains, etc., in a part of Beacon street, Boston.

Proviso.

Damages.

SECTION 2. Any damages occasioned by the taking of land or any right therein under authority hereof shall be ascertained and recovered in the manner provided by law in the case of land or rights therein taken for the laying out of ways in the city of Newton, and any damages which the city of Boston shall be required to pay by reason of said sewers and drains being in said territory, or by reason of any act or neglect of the city of Newton in placing them therein, shall be repaid to the city of Boston by the city of Newton.

Assessment of betterments, etc.

SECTION 3. The city of Newton is hereby authorized to lay, assess and collect sewer assessments upon the land in the city of Newton abutting upon said Beacon street, and upon any other land in the city of Newton which is benefited by said sewers, in the same manner in which sewer assessments now are or hereafter may be laid, assessed and collected in that city.

SECTION 4. This act shall take effect upon its passage. [*Approved June 16, 1902.*

[CHAPTER 488.]

AN ACT TO PROVIDE FOR SUPPLYING THE TOWN OF WAKEFIELD WITH WATER.

Be it enacted, etc., as follows:

Town of Wakefield may be admitted into the metropolitan water district, etc.

SECTION 1. The metropolitan water and sewerage board shall on application admit the town of Wakefield into the metropolitan water district and furnish water to the same on the terms prescribed by chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five, subject however to the provisions of sections fourteen and fifteen of this act.

. . . .

Question of acceptance to be submitted to voters.

SECTION 16. This act, except as provided in section seventeen, shall take effect upon its acceptance by a majority vote of the voters of the town of Wakefield present and voting thereon at the next annual town meeting, or at a special town meeting called for the purpose within two years after its passage; but the number of meetings so specially called shall not exceed three. . . .

When to take effect.

SECTION 17. So much of this act as authorizes its submission to the legal voters of said town shall take effect upon its passage, but it shall not take further effect until accepted as hereinbefore provided by the legal voters of said town. [*Approved June 19, 1902.*

[Chapter 535.]

An Act relative to protecting the purity of water by the metropolitan water and sewerage board.

Be it enacted, etc., as follows:

Certain rules and regulations not to be enforced until certain works are constructed.

Section 1. The metropolitan water and sewerage board shall not in the case of any manufacturing plant or tannery now in operation upon the watershed of the south branch of the Nashua river above the main dam in Clinton enforce the rules and regulations made by the state board of health under the provisions of chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five, and acts in amendment thereof and in addition thereto, until said board has constructed works for the removal or purification of manufacturing refuse or polluting liquid incident to or resulting from the processes of such manufacturing plant or tannery: *provided*, that the owner of such manufacturing plant or tannery consents, without charge therefor, to the construction of suitable works upon his land and within his buildings so far as such works can be constructed thereon or therein. The amount paid for such works shall be considered as a part of the expense of construction of the metropolitan water works, and such works shall be maintained and operated as a part of said water works.

Proviso.

Section 2. This act shall take effect upon its passage. [*Approved June 27, 1902.*

RESOLVES.

[Chapter 112.]

Resolve relative to an investigation of the improvement of Spot Pond brook by the metropolitan water and sewerage board.

Condition of Spot Pond brook to be investigated, etc.

Resolved, That the metropolitan water and sewerage board is hereby authorized and directed to investigate the condition of Spot Pond brook in Stoneham, Melrose and Malden, and to report a plan for such improvements to the brook as will provide for the easy and natural flow to tide water of the water from Doleful pond and surrounding country turned into it by said board. The board shall take into consideration the whole question of the improvement of the brook, shall ascertain what troubles are to be remedied, and by what methods the needed improvements may be effected, and shall give public notice and a hearing to all persons interested. If the board finds that such

plan and improvements are feasible and desirable, it shall recommend a plan for apportioning the expense of the improvements between the Commonwealth and towns and cities benefited, and the extent, if any, to which betterments should be imposed upon abutting owners. Said report shall be made to the general court before the fifteenth day of January in the year nineteen hundred and three. [*Approved June 11, 1902.*

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